AD-A071 775 HUMAN RESOURCES RESEARCH ORGANIZATION ALEXANDRIA VA F/G 5/2

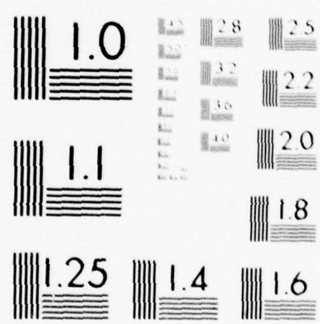
AAFCS M33 TECHNICIAN TRAINING PROGRAM. VOLUME III. ACQUISITION --ETC(U)

JUN 58 DA-49-106-QM-1

UNCLASSIFIED NL

1 OF 4

AD A071775




MICROCOPY RESOLUTION TEST CHART
NATIONAL BUREAU OF STANDARDS-1963-A

UNCLASSIFIED

SECURITY CLASSIFICATION OF THIS PAGE (When Data Entered)

## REPORT DOCUMENTATION PAGE

READ INSTRUCTIONS BEFORE COMPLETING FORM

**1. REPORT NUMBER**

**2. GOVT ACCESSION NO.**

**3. RECIPIENT'S CATALOG NUMBER**

**4. TITLE (and Subtitle)**

(6) AAFCS M33 TECHNICIAN TRAINING PROGRAM. Volume III. ACQUISITION RADAR.

A071774

**5. TYPE OF REPORT & PERIOD COVERED**

(9) Research Product rept.

**6. PERFORMING ORG. REPORT NUMBER**

**7. AUTHOR(s)**

**8. CONTRACT OR GRANT NUMBER(s)**

(15) DA-49-106-qm-1

**9. PERFORMING ORGANIZATION NAME AND ADDRESS**

Human Resources Research Organization (HumRRO)
300 North Washington Street
Alexandria, Virginia 22314

**10. PROGRAM ELEMENT, PROJECT, TASK AREA & WORK UNIT NUMBERS**

**11. CONTROLLING OFFICE NAME AND ADDRESS**

Department of the Army
Washington, D.C.

**12. REPORT DATE**

(11) Jun[redacted]58

**13. NUMBER OF PAGES**

290

**14. MONITORING AGENCY NAME & ADDRESS (if different from Controlling Office)**

(12) 297p.

**15. SECURITY CLASS. (of this report)**

Unclassified

**15a. DECLASSIFICATION/DOWNGRADING SCHEDULE**

**16. DISTRIBUTION STATEMENT (of this Report)**

Approved for public release; distribution unlimited.

**17. DISTRIBUTION STATEMENT (of the abstract entered in Block 20, if different from Report)**

**18. SUPPLEMENTARY NOTES**

Research performed by HumRRO Division No. 5, Fort Bliss, Texas, under project RADAR VI.

**19. KEY WORDS (Continue on reverse side if necessary and identify by block number)**

Lesson Plans
Practical Exercises
AAFCS M33
acquisition radar subsystem

**20. ABSTRACT (Continue on reverse side if necessary and identify by block number)**

This is volume III of six volumes of training material prepared for an experimental course of maintenance instruction on the AAFCS M33. This volume contains instructional material for the Acquisition Radar subcourse of a program of fire control radar instruction. It includes lesson plans and practical exercises designed to be covered in 195 periods.

405 260 JM

DD FORM 1 JAN 73 1473 EDITION OF 1 NOV 65 IS OBSOLETE

UNCLASSIFED

SECURITY CLASSIFICATION OF THIS PAGE (When Data Entered)

**Technical Supplementary Material**

**for**

**HumRRO Technical Report 46:**
**DEVELOPMENT AND EVALUATION OF AN EXPERIMENTAL PROGRAM OF INSTRUCTION FOR FIRE CONTROL TECHNICIANS (RADAR VI)**

**Lesson Plans**
**Practical Exercises**

Prepared By
U.S. Army Air Defense Human Research Unit

Under the Technical Supervision of
The George Washington University
Human Resources Research Office
operating under contract with
The Department of the Army

Fort Bliss, Texas
June 1958

## FOREWARD

This is volume III of six volumes of training material prepared for an experimental course of maintenance instruction on the AAFCS M33. This material was developed during research conducted by the U. S. Army Air Defense Human Research Unit at Fort Bliss, Texas, in cooperation with the U. S. Army Air Defense School. A detailed account of the research, the results and recommendations emerging from the experiment, and the rationale by which this material was prepared and used, is included in HumRRO Technical Report 46, "Development and Evaluation of an Experimental Program of Instruction for Fire Control Technicians." It is recommended that readers familiarize themselves with the contents of this report before attempting to use the training materials contained in these volumes. A copy of this report may be obtained by writing to the Director, Human Resources Research Office, The George Washington University, Washington 7, D. C.

VOLUME III

ACQUISITION

TABLE OF CONTENTS

TABLE OF CONTENTS (continued)

TABLE OF CONTENTS (continued)

TABLE OF CONTENTS (continued)



---

1/ Diagrams refer to drawings which have been specially prepared by the authors.

# INTRODUCTION

This volume contains instructional material for the Acquisition Radar subcourse of a program of fire control radar instruction, which consists of the following subcourses:

| | |
|---|---|
| I | Operation Orientation |
| II | Electronic Fundamentals |
| III | Acquisition Radar |
| IV | Track Radar |
| V | Computer |
| VI | Maintenance and Supply |

It includes lesson plans and practical exercises designed to be covered in 195 periods: 105 periods of conference and 90 periods of practical exercise. Each instructional period was approximately 50 minutes in length. A detailed breakdown of instructional topics and time allotment is presented in table 1, page 3.

This subcourse is designed to provide the student with the information and skills necessary to maintain, repair, and adjust the acquisition radar subsystem of the AAFCS M33.

Instructional material contained herein is that issued to instructors. Material issued to students was identical with two exceptions: (1) copies of practical exercises were not issued, and (2) instructor's notes, suggested explanations, and problems (shown in boxes in the lesson plans) were deleted.

A difference in format exists between material in this volume and that used during the research, in that the experimental lesson plans were printed only on the left-hand pages of the volumes. This arrangement provided student and instructor with convenient and appropriate space for notes.

Instruction in the configuration and operation of several circuits which we normally covered in the Electronic Fundamentals (Basic Electronics) subcourse is included in this volume so that these circuits may be discussed in conjunction with the specific portions of the AAFCS M33 of which they are a part. To insure proper instructional coverage of these circuits as they are encountered in the text of this volume, the initial reference to each circuit is indicated by means of an arrow placed in the margin. The presence of an arrow indicates to the instructor that the circuit in question is new to the student and will require introductory coverage.

It will be noted that each page of lesson plans and practical exercises is coded at the top of the page. This code is interpreted as follows: the first letter "I" indicates that these are instructor materials, the second letter indicates the volume (in this case, "A" for Acquisition Radar), and the number following the dash indicates the number of the lesson plan in the volume. The code found on practical exercises is similar except that "P" precedes the number following the dash.

Experience gained during the course of an experiment frequently enables researchers to suggest modifications in design and/or material that should lead to significant improvement of the product. Such modifications have been incorporated into these volumes to the possible benefit of the user and are indicated in two ways:

1. Changes relating to content are described in the introduction to each volume. No such changes have been recommended for volume III.

2. Changes relating to topic time allotments are indicated in table 1. Numbers indicate recommended hours of instruction for each topic. Where recommended time differs from time actually allotted during the experiment, actual time consumed during the experiment is indicated in parentheses.

Although materials in this volume have been carefully prepared, imperfections may still exist. Your cooperation in eliminating them is requested. Notification of errors and suggestions for improvement should be forwarded to the Director of Research, U.S. Army Air Defense Human Research Unit, Fort Bliss, Texas.

Table 1

**SUMMARY OF INSTRUCTIONAL* PERIODS ALLOTTED TO TOPICS INCLUDED IN THE ACQUISITION RADAR SUBCOURSE**

| TOPIC | CONFERENCE | PRACTICAL EXERCISE |
|---|---|---|
| AAFCS M33 Block | 3 | 3 |
| AC Distribution | 4 | 3 |
| Delay Timers and Power Supplies | 11 (12) | 9 (10) |
| Synchronizer | 2 (4) | 2 (3) |
| Test Amplifier | 2 (4) | 2 (3) |
| Acquisition Radar Block | 3 (4) | 3 |
| Acquisition Transmitter | 3 | 6 |
| Acquisition RF System | 4 | 3 |
| Acquisition Receiver Block | 4 | 3 |
| Acquisition Receiver | 8 | 6 |
| Acquisition AFC | 8 | 6 |
| MTI | 8 | 6 |
| PPI | 8 | 6 |
| Target Designator Block | 4 | 3 |
| Target Designator | 16 | 12 |
| Designation-Precision Indicator | 4 | 3 |
| Acquisition Radar Review | 4 | 3 |
| Examinations | 6 | 9 |
| Critiques | 3 | 2 |
| Total | 105 (111) | 90 (93) |

* Does not include 36 periods of nonacademic time: Commander's time, physical training, etc.

# LESSON PLAN

## AAFCS M33 BLOCK DIAGRAM

OBJECTIVE:

To explain the function, operation, and location of the component parts of the AAFCS M33 fire control system on a block level.

PRESENTATION:

1. Use of the Schematic Diagrams.

   a. The index is shown on pages 3 through 8.

   b. Schematic symbols and their explanations follow the index.

   c. The location diagrams (figs XVI through XXII)[2/] show the physical location of each chassis in the system.

2. AAFCS M33 Simplified Block Diagram.

   a. The heart of the AAFCS M33 system is the pulse synchronizer.

      1) There are two outputs, the preknock pulse and the sync pulse.

         a) The preknock pulse initiates the action of all the sweep and range circuits in both the acquisition and the track radar.

         b) The sync pulse synchronizes both the track and acquisition radars.

---

2/ Figures are direct references to the Antiaircraft Fire Control System M33 Schematic Diagrams, the Antiaircraft and Guided Missile School, Fort Bliss, Texas.

2) The prf for both the preknock and sync pulses is approximately 930 pulses per second (pps) when the synchronizer is free running and 1, 000 pps when in autosync.

3) The preknock pulse appears 5 microseconds before the sync pulse so that the sweep and range circuits will be ready when the transmitter fires.

4) The autosync pulse synchronizes the pulse synchronizer at 1, 000 pps.

b. The acquisition radar searches continuously.

1) The peak power output of the acquisition transmitter is approximately one megawatt.

2) The transmitter when synchronized by the sync pulse has a prf of 930 to 1, 000 pps.

3) The carrier frequency is adjustable from 3, 100 to 3, 500 megacycles.

4) The PPI display is 360° in azimuth and either 60, 000 or 120, 000 yards in range.

5) The target-designator system provides the means of integrating the acquisition and track radars.

c. The track radar tracks the target automatically in azimuth, elevation, and range.

1) The purpose of the track radar is to provide the computer with the observed azimuth and elevation angles and the slant range to the target.

2) The transmitter is synchronized by the sync pulse and has a prf of 930 to 1, 000 pps.

3) The peak power output is approximately 250, 000 watts.

4) The carrier frequency is adjustable from 8,500 to 9,600 megacycles.

5) The tracking indicators when utilizing A-type presentation show 100,000 yards in range.

6) The track radar furnishes the computer with the target's present azimuth angle, elevation angle, and a voltage representing the target's slant range.

d. The computer predicts the future position of the target that is being tracked.

1) The computer converts spherical-coordinate input data to rectangular coordinates.

2) Ballistic and parallax corrections are set in on the correction panel.

3) The rate of the target is computed, and, based on this rate, the future position of the target is predicted.

4) The outputs of the computer, firing azimuth, firing elevation, and fuse setting are fed to the guns.

e. The plotting boards provide a permanent record, in the form of a continuous plot, of the tracking mission and target course.

1) The horizontal plotting board shows both the present and predicted range and azimuth.

2) The present-altitude board records the observed ground range $R_o$ and the observed altitude $H_o$.

3) The predicted-altitude plotting board displays the future position of the target in ground range $R_p$ and firing altitude $H_f$.

3. AAFCS M33 Complete Block Diagram (fig 1-1).

| |
|---|
| **INSTRUCTOR'S NOTE**: Point out the location as each stage is covered. |

a. Synchronizer System.

1) The synchronizer consists primarily of a blocking oscillator, two cathode followers, and a 5-microsecond delay line.

2) The blocking oscillator provides a positive, 2-microsecond pulse for both cathode followers.

3) The output of one cathode follower (CF) is a positive, 25v pulse called the preknock pulse.

4) The other CF is identical to the first except that the output is fed through a 5-microsecond delay line. This output, the sync pulse, is 20 volts in amplitude.

5) The sync and preknock pulses are used in the acquisition and the track radars to provide a definite time relation between the transmitting, range, and sweep circuits of both radars.

b. Acquisition Radar.

1) The preknock pulse times the range and sweep circuits, and the sync pulse initiates transmitter action.

2) The transmitter consists of a trigger generator, a modulator, a pulse transformer, and the magnetron.

a) In the trigger generator, the sync pulse triggers a blocking oscillator.

1. The output of the blocking oscillator is used to trigger the trigger generator thyratron switch tube.

2. When triggered, the switch tube discharges a pulse-forming network through the primary winding of a transformer, thereby building up the output pulse.

3. The transformer steps up the 600v pulse at its primary so that the output to the modulator is a positive, 2-microsecond, 850v pulse.

b) The modulator is similar to the trigger generator.

1. The positive, 850v pulse triggers the thyratron switch tube in the modulator.

2. This switch tube discharges the pulse-forming network through the pulse transformer.

3. The pulse at the primary of the pulse transformer is a negative, 4 to 8 kv, 1.3 microseconds in duration.

c) The pulse transformer steps up the pulse, without polarity inversion, to approximately 38 to 45 kv and applies it to the magnetron.

d) The magnetron is shocked into oscillation when the high-voltage pulse is applied to its cathode.

1. The tuning drive varies the magnetron frequency.

2. The magnetron output is fed directly into the waveguide through a coupling window.

3) The radio-frequency (rf) system includes the waveguide, duplexer, rotary joint, pillbox radiator, and reflector.

a) The waveguide conveys the rf from the magnetron to the pillbox radiator and the return echo from the pillbox radiator to the receiver.

b) The duplexer includes the ATR tubes, the TR tube, and the Y-junction.

1. The TR tube protects the receiver from the transmitted pulse.

2. The ATR tubes prevent the return echo from being absorbed by the magnetron.

c) The pillbox radiator serves to focus the beam into the reflector.

d) The reflector varies the beam pattern and elevation by the injection of cosecant bars.

e) The directional coupler provides a means of checking the frequency, power, and standing-wave ratio.

4) The receiver converts the return echo into an intermediate frequency (if) signal, amplifies and detects the signal, and applies the target video to the presentation system.

a) The AFC unit maintains the if signal at 60 megacycles above the transmitted frequency.

b) The mixer channel mixes the return echo with the local-oscillator output to obtain the if signal.

c) The intermediate frequency preamplifier amplifies the if signal at the barbette to overcome cable losses and to provide a high signal-to-noise ratio.

d) The sensitivity time control (STC) provides reduced gain at close ranges to cut down the blossom from ground clutter on the PPI.

e) The intermediate frequency amplifier amplifies and detects the signal, applying negative bypass video to the switcher-mixer and positive video to the MTI system.

f) The MTI system eliminates fixed target echoes out to a maximum range of 35, 000 yards. (In system 725 and above, MTI extends to 120, 000 yards.)

1. When operating, the MTI system has only moving-target video as its output.

2. The negative MTI video is applied to the switcher-mixer.

g) The switcher-mixer switches from MTI to bypass video at a range determined by the setting of the operating controls and mixes in the IFF information.

h) The video-and-mark channel receives the composite video signal and the marks necessary for indicator display.

1. The marks necessary to produce the range circle, the flashing azimuth line, and the electronic cross are mixed with the video.

2. The output is applied to the presentation and target designator system.

5) The presentation system amplifies and presents the video and marks on a PPI type display.

a) The PPI sweep rotates in synchronism with the rotation of the acquisition antenna.

b) The sweeps may rotate at 10, 20, or 30 rpm.

6) The target designator provides a rapid means of selecting and designating a target.

a) The designation-control system designates the target and relays target data in order to position the tracking system in azimuth and range.

1. The acquisition-range computer generates the ACQ range mark which appears as the range circle on the PPI.

2. The ACQ track range mark (the arc of the electronic cross) is compared with the ACQ range mark to position the track range unit at the designated range.

3. The designated azimuth is available to the track radar antenna-positioning system through the use of synchros positioned by the RING DEPRESS switch.

4. The azimuth of the track radar is shown by the track-azimuth mark (radial line of the electronic cross) generated in the track-mark generator.

b) The designation presentation system displays a 30° by 5, 000-yard segment of the PPI presentation centered on the junction of the range circle and the flashing azimuth line or on the electronic cross.

1. The azimuth-sweep channel forces the electron beam to travel, from left to right, across the face of the CRT.

2. The sweep is forced from the bottom to the top of the CRT by a signal from the range-sweep channel.

3. There are several range sweeps during each azimuth sweep.

c. Track Radar.

1) The preknock pulse times the range and sweep circuits, and the sync pulse initiates transmitter action.

2) The transmitter is almost identical in circuitry and operation to the acquisition transmitter.

a) The trigger generator, timed by the sync pulse, generates a 450v, positive, 5-microsecond pulse which triggers the modulator.

1. The trigger pulse is generated by a blocking oscillator.

2. The output of the blocking oscillator is applied to the grid of the switch tube in the modulator through a cathode follower.

b) The modulator builds up a 7 to 8 kv 0.25-microsecond pulse for application to the primary of the pulse transformers.

1. When the trigger pulse is applied, the switch tube discharges the pulse-forming network through the pulse transformer.

2. The pulse transformer steps up the negative pulse, without inversion, to 25 or 30 kv.

3. The pulse is applied to the cathode of the magnetron.

c) The magnetron oscillates at 8,500 to 9,600 megacycles.

d) The burst of rf energy is coupled into the waveguide.

3) Essentially, the rf system consists of the waveguide, duplexer, rotary joint, feedhorn, and the antenna lens.

a) The waveguide conducts the transmitted energy to the feedhorn and the return echo from the feedhorn to the receiver.

b) The ATR tubes prevent the return echo from being absorbed by the magnetron.

c) The TR tube prevents the transmitted pulse from damaging the receiver and allows the return echo to enter the receiver.

d) The feedhorn and the antenna lens focus the rf energy into a very narrow beam in azimuth and elevation.

4) The track receiver system receives, amplifies, and detects the return echo to produce video for the presentation system.

a) The balanced converter mixes the return signal with the local-oscillator output to produce the signal intermediate frequency. It also mixes the local-oscillator output with a sample of the transmitted frequency to obtain the proper input to the AFC unit.

b) The AFC unit maintains the local-oscillator output at 60 megacycles above the magnetron frequency.

c) The if preamplifier amplifies the return signal at the antenna to overcome cable losses and provide a high signal-to-noise ratio.

d) The if amplifier further amplifies the signal and detects the video component.

e) The video is amplified by video amplifiers on each track indicator unit and applied to the A-scopes.

5) The range tracking system produces one of the three outputs of the track radar: $D_o$, the observed slant range to the target.

a) The track-range unit generates the following signals:

1. The track range mark which times the expansion-pulse channel,

2. The track range gate, used in the target designator to show the tracking range on the PPI and precision indicators,

3. The ACQ track range mark which forms the arc of the electronic cross,

4. The 500-yard expansion pulse and the 100-yard notch, used to indicate the tracking range on the A-scope, and

5. The 35-yard gate, used for automatic range tracking.

b) The range-servo system positions the phase-shift capacitor, the pip-selector potentiometer, and the range-data potentiometer.

c) The range-data potentiometer feeds its output, a voltage representing slant range, to the computer.

6) The track antenna positioning system positions the antenna automatically in azimuth and in elevation.

a) The azimuth and elevation angle detectors compare the envelope of the modulated video signals with a reference voltage and develop an output which is proportional to the error in azimuth and elevation.

b) The azimuth and elevation servo systems drive the antenna in azimuth and elevation in accordance with the signal obtained from either the handwheels or the angle detectors.

7) The tracking indicators provide visual indication of the target.

a) The indicators show range information, primarily. Pip matching is employed when in the SEL SIG position.

b) The sweep on each indicator may extend to a range of 100, 000 yards.

8) The trial-fire indicator.

a) The trial-fire indicator uses a 3-inch CRT that permits the display of signals which occur within 250 yards of the track range setting.

b) Circuits in the trial-fire indicator operate in conjunction with the time-to-burst integrator in the computer to measure, in seconds, the exact interval between the firing of the gun and the shell burst.

d. Computer.

1) The observed-target coordinates section receives slant range from the track range unit and the azimuth and elevation angles from the mechanical position of the track antenna.

a) With this information, the rectangular coordinates, $X_o$, $Y_o$, $R_o$, and $H_o$, are obtained.

b) The rectangular coordinates are fed to the prediction-coordinates section and the predicted target coordinates section.

2) The prediction-coordinates section computes the target rate in X, Y, and H directions. The output is fed to the predicted target coordinates section.

3) The predicted target coordinates section computes the future position of the target.

a) The present position of the target is combined with the output of the predicted target coordinates section to provide the future position data.

b) Parallax corrections are also added in this section.

4) The azimuth servo furnishes the firing azimuth to the guns through the use of a fine- and coarse-synchro system.

a) Ballistic corrections are added to the predicted position to produce the firing azimuth.

b) The predicted ground range, another output from this section, is fed to the ballistic-coordinates section.

5) The ballistic-coordinates section computes the firing horizontal range and altitude by adding ballistic corrections to the predicted horizontal range and the altitude. The output is fed to the elevation servo.

6) The elevation servo is positioned by the input from the ballistic-coordinates section.

a) The elevation servo furnishes the guns with the firing elevation through the use of a fine- and coarse-synchro system like that of the azimuth servo.

b) The firing slant range is another output of the elevation servo which is fed to the time-of-flight[3/] servo.

7) The time-of-flight servo combines the output from the elevation servo with a correction factor from the ballistic-synthesis section. The result, representing time to burst, is fed to the fuze servo.

8) The fuze servo combines the time of flight with muzzle velocity, air density, and the dead time to produce the fuze setting. The output is fed to the guns through a synchro transmitter.

9) The ballistic-synthesis section produces voltages to correct for nonstandard conditions and the effects of gravity.

e. Plotting Boards.

1) The horizontal plotting board shows both the present and predicted position of the target in range and azimuth out to a maximum range of 40, 000 yards.

a) Range circles are provided at 5, 000-yard intervals.

b) Azimuth lines are etched at 200-mil increments.

---

3/ This may be called the time-to-burst servo.

c) A horizontal and vertical reference line is provided to facilitate the use of overlays on standard military maps.

2) The present-altitude plotting board is marked with range circles at 5, 000-yard intervals and altitude lines at 2, 000-yard intervals.

a) The range may be plotted out to 40, 000 yards.

b) The present-altitude board plots from -500 to 20, 000 yards.

3) The predicted-altitude plotting board plots range out to 14, 000 yards and altitude from -500 to 14, 260 yards.

## PRACTICAL EXERCISE

### INTRODUCTION TO AAFCS M33

AAFCS M33 SETUP: The equipment and generator should be turned off.

EQUIPMENT NECESSARY: None.

DEMONSTRATION:

1. The proper start-stop procedure for the generator should be demonstrated.

   a. Each student should have a chance to start and stop the generator.

   b. The procedure for switching from the main to the auxiliary gasoline tanks will be explained.

   | INSTRUCTOR'S NOTE: Show the students where to adjust the throttle rod in case the motor does not rev up when the throttle is pushed in. |
   |---|

2. Show the location, with a brief explanation of function, of the following.

   a. The synchronizer.

   b. The acquisition trigger generator.

   c. The ACQ modulator.

   d. The magnetron and rf system.

   e. The receiver including:

   1) The intermediate frequency preamplifier,

2) The AFC unit,

3) The local oscillator,

4) The if amplifier,

5) The switcher-mixer,

6) The video-and-mark mixer, and

7) The video amplifier on the PPI.

f. The PPI and precision indicators.

g. The monitor-control panel.

h. The track trigger generator.

i. The track modulator.

j. The track magnetron and rf system.

k. The track receiver including:

1) The track ATC,

2) The if preamplifier,

3) The local oscillator,

4) The if amplifier,

5) The pulse demodulator, and

6) The video amplifier on the track indicators.

l. The antenna-positioning control including:

1) The low-power servo amplifier,

2) The high-power servo preamplifiers, and

3) The high-power servo amplifiers.

m. The low-voltage and the transmitter high-voltage power supplies.

n. The computer including:

1) The power supplies,

2) The dc amplifiers,

3) The indicators for bad dc amplifiers, and

4) The plotting boards.

3. The remaining period should be utilized for equipment operation.

| |
|---|
| INSTRUCTOR'S NOTE: Students not engaged in operating the equipment should be learning the names of the major components. |

# LESSON PLAN

## AC DISTRIBUTION

**OBJECTIVE:**

To explain the operation of the ac distribution system.

**INTRODUCTION:**

The AAFCS M33 with its generator is a completely self-contained radar system, and the many dc voltages necessary for the proper operation of the equipment are provided by power supplies in the equipment. These power supplies deliver dc potentials by rectifying the ac input. The majority of the motors in the AAFCS M33 and the filaments of the tubes require ac current for excitation.

It is the purpose of this lesson to present the ac distribution circuits, to point out the function and location of the various components of those circuits, and to provide information which will prove useful in maintaining the equipment in the field.

| |
|---|
| INSTRUCTOR'S NOTE: The block diagram (fig 1) should be used for tie-in with previous instruction. |

**PRESENTATION:**

1. Generator.

   a. The primary source of ac power for the AAFCS M33 is a 400-cycle generator.

      1) The frequency of the ac power may be adjusted at the generator.

      2) The amplitude of the ac power may be controlled either at the generator or from the control panel at the radar cabinet.

INSTRUCTOR'S NOTE: Point out that power is applied to the LINE VOLTAGE meter when the generator MAIN POWER switch is ON.

b. The generator supplies three-phase power over a four-wire system.

1) The potential between phases is 208 volts.

2) The potential between any phase and neutral is 120 volts.

2. MAIN POWER Switch (fig 19-1).

INSTRUCTOR'S NOTE: Point out to the students that this lesson follows, step by step, the energizing procedure for the equipment.

a. When the MAIN POWER switch is operated, ac power is applied to several units in the system.

INSTRUCTOR'S NOTE: When tracing distribution, it will be easier for the student to see if you start at the end and work back.

1) Phase A is applied to the convenience outlets inside the van.

2) Phase C is applied to the battery charger (leads going to fig 19-68).

INSTRUCTOR'S NOTE: Schematic error (fig 19-68): Input power should read phase C.

3) Three-phase power is applied to the PERSONNEL VENTILATION switch S8.

4) Three-phase power is applied to the EQUIPMENT VENTILATION switch S10.

5) Three-phase power is applied to the computer MAIN POWER switch S1 (leads going to fig 23-2).

6) Three-phase power is applied to the RADAR POWER switch S2.

7) Phase A is applied to the ceiling lights (fig 14-95).

b. Each circuit is fused and provided with a red indicator that glows if the fuse overheats and opens.

3. RADAR POWER Switch.

a. When the RADAR POWER switch is operated, phase A is applied to the following:

1) The ACQUISITION POWER switch (figs 19-2, 19-6, and 19-66),

2) The TRACK FILAMENTS switch (figs 19-2 and 19-15),

3) The barbette, radar cabinet, tracking console, track antenna, and tactical control console for filament power,

4) Transformer T12 (fig 19-10) for servo and tach excitation,

5) The acquisition, high-voltage power supply through contacts of K1/A (fig 19-62),

6) The track, high-voltage power supply, through contacts of K3/A (fig 19-64), and

7) Power transformer T1, the 30-second delay timer (fig 19-60).

b. When the RADAR POWER switch is operated, phase B is applied to the following (fig 19-1):

1) Contacts of relay K5 (fig 19-5) which is energized by operating the LOW VOLTAGE switch (fig 19-60),

2) Transformer T12 (fig 19-10), for servo and tach excitation,

3) The HP SERVOS switch (fig 19-11),

4) The TRACK FILAMENTS switch (fig 19-15),

5) The acquisition, high-voltage power supply through contacts of K1/A (fig 19-62),

6) The track, high-voltage power supply through contacts of K3/A (fig 19-64),

7) The ACQUISITION POWER switch (fig 19-66), and

8) ACQUISITION MOTORS switch (fig 19-67).

c. When the RADAR POWER switch is operated, phase C is applied to the following (fig 19-1):

1) The ACQUISITION POWER switch (fig 19-6),

2) Contacts of K15/A (figs 19-6 and 19-7),

3) Transformer T3, -28v power supply (fig 19-90),

4) Some of the low-voltage power supplies as primary and filament power,

5) The radar cabinet blower motors (fig 19-14),

6) The HP SERVOS switch (fig 19-11),

7) The TRACK FILAMENTS switch (fig 19-15),

8) The acquisition, high-voltage power supply through contacts of K1/A (fig 19-62),

9) The ACQUISITION POWER switch (fig 19-66), and

10) The ACQUISITION MOTORS switch (fig 19-67).

4. LOW VOLTAGE Switch (fig 19-60).

   a. The LOW VOLTAGE switch, when operated after the 30-second delay, supplies ground to energize relay K5/A.

   b. When energized, K5/A supplies phase B to the following points:

      1) The INDICATOR HV switch (fig 19-5),

      2) The +270v power supply (fig 19-90),

      3) The +220, +70, and -250v power supply (fig 19-89),

      4) The +450v power and +250v regulator (fig 19-84), and

      5) The +320v, +320v power supply (fig 19-88).

5. INDICATOR HV Switch (fig 19-5).

When the INDICATOR HV switch is operated, phase B is applied to the following:

   a. T2/B24, filament supply for the indicator, high-voltage power supply (fig 19-5 to fig 19-53), and

   b. T3/B24, high-voltage ac input to the indicator, high-voltage power supply (fig 19-83).

6. ACQUISITION POWER Switch (fig 19-2).

   a. When the ACQUISITION POWER switch is operated, phase A is applied to the following:

      1) ACQ, high-voltage power supply for filament power (fig 19-53),

      2) Hydraulic pump motor in the barbette (fig 19-66),

      3) ACQ modulator filament supply (fig 19-57),

      4) Convenience outlets in the barbette (fig 19-2),

5) The start relay in the 15-minute delay timer (figs 19-2 to 19-62),

6) Filament supply for the ACQ local-oscillator if preamplifier, AFC unit, and the low-power servo amplifier (fig 19-2 leads to fig 19-46), and

7) Filament supply for the resolver amplifier (fig 19-2 leads to fig 19-52).

b. When the delay timer action has been initiated by the ACQUISITION POWER switch, relay K9/A energizes, applying phase A to the local-oscillator power supply (fig 19-2 leads to fig 6-3).

7. TRACK FILAMENTS Switch (fig 19-2).

a. When the TRACK FILAMENTS switch is operated, phase A is applied to the following:

1) Filament of the track magnetron (fig 19-2 leads to fig 19-50),

2) The start relay and five-minute delay timer (fig 19-2 leads to figs 19-64 and 12-4), and

3) Filaments of the local-oscillator AFC unit and the if preamplifier (fig 19-2 leads to fig 19-50).

b. When the delay timer has started its operation, K7/A energizes and applies phase A to the rectifier, supplying keep-alive voltage to the TR tube and to the solenoids which extract the shutter (figs 19-64 and 13-2).

8. EXCITATION Switch (fig 19-10).

a. When the EXCITATION switch is operated, -28v is supplied to relay K15/A.

b. With -28v applied, K15/A energizes, supplying excitation to the following:

1) Synchros in the track antenna positioning system,

2) High-power servo preamplifiers (fig 19-10 leads to figs 19-12 and 16-15),

3) Range, azimuth, and elevation servo channels,

4) Optics servo (fig 16-14 leads to figs 19-13 and 19-10),

5) ACQ range control channel (fig 9-5), and

6) Azimuth and elevation angle detectors (fig 16-6).

c. Tach excitation is applied to the tachometers when relay K15/A is energized (fig 19-10).

d. Motor excitation is applied, through contacts of K15/A, to the following (fig 19-7):

1) Track-azimuth drive motors (fig 16-8),

2) TRACK RANGE dial fine- and coarse-synchros (fig 15-13),

3) ELEVATION handwheel and intermediate motors (fig 16-10),

4) AZIMUTH handwheel and intermediate motors (fig 16-7),

5) ACQ range control channel (fig 9-5),

6) Motors in the track range servo (fig 15-12),

7) Elevation drive motor (fig 16-11),

8) ELEVATION dial fine- and coarse-synchros (fig 16-12),

9) Optical servo system (fig 16-14), and

10) Azimuth fine- and coarse-synchros (fig 16-9).

9. HP SERVOS Switch (fig 19-11).

a. When the HP SERVOS switch is operated, phase B is applied to the following (fig 19-11):

1) The azimuth, high-power servo amplifiers (fig 16-16), and

2) The elevation, high-power servo amplifier (fig 16-16).

b. Phase C is applied, through the antenna drive SAFETY switch, to the following (fig 19-11):

1) The azimuth, high-power servo amplifiers (fig 16-16), and

2) The elevation, high-power servo amplifier (fig 16-16).

10. ACQUISITION MOTORS Switch (fig 19-67).

a. When the ACQUISITION MOTORS switch is operated, three-phase power is applied to the following in the antenna drive:

1) The blower motors (fig 19-67),

2) Contacts of K/F1 (fig 19-67), and

3) Motor contactor K1/F1, azimuth drive motor control (fig 19-65).

b. Phase A is applied to the convenience outlet on the antenna drive when the ACQUISITION MOTORS switch is operated.

11. COMPRESSOR MOTOR ON OFF Switch (fig 19-67).

a. When the ON OFF switch is operated, solenoid K/F1 is energized.

b. Three-phase power is applied to the compressor motor through contacts of K/F1.

COMMON TROUBLES:

| | Symptoms | Probable Cause |
|---|---|---|
| 1. | Several fuses burn out when equipment is energized. | Equipment energized too rapidly. (Often, when the equipment is cold, too great a load is placed on the line by rapid energization.) |
| 2. | No action results when switch is operated. | Incorrect energizing procedure. Defective switch. |
| 3. | Fuses burn out when equipment ventilation is turned on. | Circuit overload. (Replace equipment ventilation fuses with the slo-blo type. Regular fuses will burn out because of surge currents.) |

## PRACTICAL EXERCISE

## AC DISTRIBUTION

AAFCS M33 SETUP: The equipment should be completely deenergized.

EQUIPMENT NECESSARY: Multimeter TS-352/U.

DEMONSTRATION:

> INSTRUCTOR'S NOTE: Have one of the students energize the set and point out the visual indications as each control is operated. Have the students follow the distribution circuits in the schematics.

1. The demonstration should be in the following order.

   a. Line voltage check and adjustment.

   b. Turn on MAIN POWER switch and check:

      1) Power to computer,

      2) Ceiling lights,

      3) Sound of blower motors as equipment is energized,

      4) Battery charger, and

      5) Convenience outlets.

   c. Turn on RADAR POWER switch and check:

      1) Sound of the ACQ and track motors,

      2) Filament power to radar cabinet tracking console,

      3) Energizing of 30-second delay timer,

4) ACQUISITION MOTORS switch S11, and

5) ACQUISITION AZIMUTH SCAN switch.

d. Turn on LOW VOLTAGE switch and check:

1) LOW VOLTAGE ON light on control panel, and

2) Rectifier glow in low-voltage power supplies.

e. Turn on INDICATOR HV switch and check:

1) Sweeps on track indicators, and

2) Operating controls on indicators.

| |
|---|
| INSTRUCTOR'S NOTE: Emphasize the importance of the voltage checks and the use of the operating controls. |

f. Turn on ACQUISITION POWER switch and check:

1) ACQUISITION OFF light,

2) Filament power to high-voltage power supply and modulator, and

3) Sweeps on PPI.

g. Turn on TRACK FILAMENTS switch and check:

1) TRACK OFF light, and

2) Filament power to high-voltage power supply and the modulator.

h. Turn on EXCITATION switch and check:

1) Range servo, and

2) Azimuth and elevation drive motors.

i. Turn on HP SERVOS switch and check:

   1) Dial jump when switch is operated.

   2) Sound of motors, and

   3) Antenna SAFETY switch.

j. Turn on TRACK SCANNER switch and check:

   1) Image spacing on tracking indicators, and

   2) SCAN RATE meter.

2. Show students how to locate terminal strips from the schematic references.

3. Demonstrate the proper method of making ac voltage checks with the multimeter.

| |
|---|
| INSTRUCTOR'S NOTE: Make sure that each student checks an ac voltage and caution the students about the danger involved. Tell the students that there is no need to worry about injury if they use a few simple precautions. Place a trouble in the ac distribution and demonstrate the proper method of troubleshooting. |

4. Show the students how to use the test lead for supplying ground as a test for open interlocks.

SUGGESTED TROUBLES:

> INSTRUCTOR'S NOTE: While one group of students is troubleshooting, the other group should be locating test points in the schematics. The instructor should guide the students using the schematics, showing the proper use and making sure that each student understands the symbols and the location of the components.

1. Remove fuze F1 (removes power from the convenience outlets).

> INSTRUCTOR'S NOTE: Make sure that the students know the use of the fuse indicator lights.

2. Remove terminal No. 123 tactical control console (TCC) (removes ceiling light excitation).

3. Remove LOW VOLTAGE READY lamp.

4. Open switches and terminals in the low-voltage interlock circuit.

5. Open terminal No. 31 radar control van (RC) (removes excitation to high-power servo amplifiers).

> INSTRUCTOR'S NOTE: When the students are familiar with the symbols and know how to use the schematics, students not engaged in troubleshooting should utilize time for component location.

# LESSON PLAN

## DELAY TIMERS AND POWER SUPPLIES
## (Part I)

### OBJECTIVE:

To explain the operation and repair of:

1. The low-voltage interlocks and 30-second delay timer,
2. The +450v power supply and +250v regulator,
3. The +270v, +175v, and -28v power supply.
4. Acquisition, high-voltage control circuits, and
5. The 15-minute delay timer.

### INTRODUCTION:

In the AAFCS M33 radar sets or any type of electronic equipment, a great variety of voltages are necessary for proper operation. In this lesson, a few of the power supplies and the control circuits for those power supplies will be discussed.

### PRESENTATION:

1. Low-Voltage Interlock Circuit (fig 19-60).

   Interlocks in the tactical control console, the tracking console, and the radar cabinet must be closed before the LOW VOLTAGE READY light will operate.

   a. All the low-voltage interlocks may be bypassed by use of the OVERRIDE switch. The OVERRIDE switch should be used to prevent damage to the equipment when opening or closing doors on either the console or the radar cabinet. The OVERRIDE switch does not override the interlocks in the barbette or tracking antenna.

b. In addition to the low-voltage interlocks, the end relay K1 (30-second delay timer) must be energized before the LOW VOLTAGE READY light will operate.

> INSTRUCTOR'S NOTE: Conduct the student through a trouble, having him suggest the methods to be used and correcting continuously as he progresses.

2. 30-Second Delay Timer (fig 19-60).

a. When the RADAR POWER switch is operated, 120 volts phase A is applied to the 30-second delay timer.

b. V1 is a full-wave rectifier.

c. V2 establishes a bias which holds V3 at cutoff.

d. The charge on C1 opposes the bias set up by V2.

e. When the charge on C1 rises sufficiently, the charge overcomes the bias set up by V2 and V3 will conduct.

f. The charge time of C1 determines the length of time V3 is held cutoff.

g. End relay K1, in the plate circuit of V3, energizes when V3 conducts.

h. When K1 is energized, the LOW VOLTAGE READY light comes on.

> INSTRUCTOR'S NOTE: Explain the adjustment of the 30-second delay timer.

3. LOW VOLTAGE Switch.

a. When the LOW VOLTAGE switch is operated, K5 energizes.

b. When K5 is energized, it applies ac to the low-voltage power supplies.

INSTRUCTOR'S NOTE: Take the students through the control circuits.

4. The +450v Power Supply and +250v Regulator (fig 19-84).

a. Tubes V1 and V2 form a full-wave rectifier.

1) The grid voltage controls the time at which V1 and V2 start to conduct.

2) There are two voltages applied to the grids: The dc control voltage and an ac voltage which rides on the dc level.

3) The tubes conduct when the combined effects of the two voltages bring the grids sufficiently positive.

4) Once the tube is ionized, the plate circuit has control. The tube cuts off when the plate drops below the ionizing potential.

INSTRUCTOR'S NOTE: Explain the phase relationships existing between the ac voltages applied to the plate and grid of one of the thyratron rectifiers.

5) Filament voltage is supplied by transformer T3.

6) C6, C7, C8, and C9 are filter capacitors.

b. Driver V3 controls the dc voltage to the grids of V1 and V2, thus controlling the conduction of the rectifiers.

1) Should the +450v tend to become more positive, the grid (pin 7 of V3) also rises.

a) V3 then increases conduction with a resulting drop in plate voltage.

b) The drop at the plate of V3 (pin 9) is felt at the grids of V1 and V2 through transformer T2.

c) Since the grids are more negative, the rectifiers decrease in conduction.

d) The decrease in rectifier conduction results in a decrease in the charge across the filter capacitors, thus returning the output voltage to 450 volts.

e) If the output tends to drop, the reverse action is true.

| INSTRUCTOR'S NOTE: Go over conditions of the output decrease. |
|---|

2) The output level is set by adjusting the grid potential of V3A.

a) If the wiper arm of R7 is moved to pin 3, the grid of V3A is more positive.

b) V3A increases conduction causing the cathode of V3A to become more positive.

c) A corresponding rise is felt at the plate of V3B.

d) The grids of the rectifiers become more positive, and the output voltage becomes more positive.

3) Plate voltage for V3B is supplied by full-wave rectifier CR1 and CR2.

| INSTRUCTOR'S NOTE: Have students explain the effects of a change in output voltage and adjustment of R7. Caution students not to remove V3 while the low voltage is on. |
|---|

c. V4 maintains the output at pin M at +250 volts.

1) If the +250v output attempts to rise, the grids of V4 become positive.

2) The effective resistance of V4 decreases.

3) The plate voltage (and the output) drops back to +250 volts.

4) The reverse is true if the output attempts to decrease.

| |
|---|
| INSTRUCTOR'S NOTE: Conduct classroom troubleshooting on the power supply. |

5. The +270v, +175v, and -28v Power Supply (fig 19-90).

a. V1 and V2 form a full-wave rectifier.

1) The grids are tied to the cathodes through filament transformer T2.

2) The output is +270 volts with no filtering provided.

b. V3 is connected in series with the load.

1) There is a constant, 75v drop across V3.

2) The output is therefore +175 volts.

c. CR1 is a metallic-oxide, full-wave bridge rectifier.

1) The output is -28 volts unfiltered.

2) If the output drops to a value which causes the relays to be inoperative or to chatter, it may be stepped up by changing the tap on the secondary of T3.

6. Acquisition High-Voltage Control Circuits and 15-Minute Delay Timer.

a. The ACQUISITION POWER switch (fig 19-2) applies 120 volts phase A to the barbette, the acquisition, high-voltage power supply, filament transformer, and the acquisition, high-voltage control circuits.

1) The ACQ high-voltage control circuits are shown in figures 19-61 and 19-62.

2) When the ACQUISITION POWER switch is operated, the start relay K1/A17 located on the 15-minute delay timer, is energized.

3) When K1/A17 is energized, contacts 9 and 2 apply ground to the escape relay and to motor B1. In addition, contacts 5 and 11 apply ground (through interlocks) to relays K8 and K9.

4) When K8 is supplied with ground, contacts 2 and 9 supply ground to the ACQUISITION OFF light.

| INSTRUCTOR'S NOTE: Cover the interlock circuit. |
|---|

5) This condition exists until the end of the 15-minute delay when end relay K2/A17 energizes and supplies ground to the amber READY light.

6) The acquisition transmitter is now ready for operation.

b. When the ACQUISITION ON button is depressed, relays K1/A and K2/A are energized.

1) K1/A applies three-phase power to the ACQ high-voltage power supply and phase A to the ON light.

2) K2/A provides a holding contact for itself and K1/A and removes ground from the OFF and READY lights.

c. As mentioned previously, when the start relay energizes, ground is applied to the escape relay and to timer motor V1/A17.

1) The shaft of the motor turns, winding a spring mechanism. At the end of the 15-minute period, an arm on the shaft operates switch S1/A17.

2) When S1/A17 is operated, ground is applied to the READY light and removes ground from motor B1/A17.

3) Escape relay K3 prevents the spring mechanism from unwinding.

4) Should ground be removed from K3 which then deenergizes, the spring mechanism unwinds, and S1/A17 returns to the position shown in figure 19-62.

COMMON TROUBLES:

| Symptoms | Probable Cause |
|---|---|
| 1. PPI and A-scopes have jittering sweep. | Power supplies are overheating (open doors to power supplies). |
| 2. LOW VOLTAGE READY light will not light. | Doors on radar cabinet, tracking console, or tactical control console not tight.<br><br>Plunger on interlock bent. |
| 3. ACQUISITION READY light will not light. | Cover on barbette loose. |
| 4. ACQUISITION ON light does not come on when ON button is depressed. | Variac not turned to lower limit. |

# PRACTICAL EXERCISE

## DELAY TIMERS AND POWER SUPPLIES
## (Part I)

AAFCS M33 SETUP: The equipment should be deenergized.

EQUIPMENT NECESSARY: Multimeter.

PRELIMINARY TROUBLE:

Place a trouble in the low-voltage interlock circuit.

> INSTRUCTOR'S NOTE: The students should find the symptom and trouble while energizing the equipment. At the start of each succeeding practical exercise, turn all operating controls to minimum.

DEMONSTRATION:

1. Point out the location and give a brief explanation of the function of the following:

   a. The 30-second delay timer,

   b. The 5-minute delay timer,

   c. The 15-minute delay timer,

   d. The +450v power supply and +250v regulator, and

   e. The +270v, +175v, and -28v power supply.

2. Demonstrate the following adjustments:

   a. The 30-second delay timer, and

   b. The +450v power supply.

3. Remove the covers of the 5- and 15-minute delay timers and point out the operation when the ACQUISITION POWER and TRACK FILAMENTS switches are operated.

> INSTRUCTOR'S NOTE: Have the students perform delay-timer adjustments.

4. Replace one of the rectifier tubes in the power supply with a bad tube.

> INSTRUCTOR'S NOTE: Have the students note the difference in the glow of good and bad tubes.

5. Unground terminal No. 25 of E45.

> INSTRUCTOR'S NOTE: This trouble is designed to give the student an idea of circuit action resulting from the removal of ground. The symptoms for this trouble are as follows:
>
> 1. When the RADAR POWER switch is operated, both the acquisition and track OFF lights come on.
>
>     a. Phase A is applied to transformer T1 in the 30-second delay timer.
>
>     b. The electron path for the acquisition control circuits is as follows:
>
>         1) Start relay K1, 15-minute delay timer (controls ACQUISITION OFF light),
>
>         2) Transformer T2 (fig 19-57), and
>
>         3) Inductance L1 (fig 19-95) to ground.

INSTRUCTOR'S NOTE (continued):

c. The electron path for the track control circuits is as follows:

1) Start relay K1, 5-minute delay timer (controls TRACK OFF light), and

2) Transformer T2 (fig 19-50) to ground.

2. When the ACQUISITION POWER switch is operated, the ACQUISITION OFF light goes off.

a. The 120v input from the 30-second delay timer is applied to one terminal of the relay coil.

b. The ACQUISITION POWER switch applies 120 volts to the other terminal of the relay coil.

c. A difference in potential no longer exists across the coil, and the relay deenergizes.

3. When the FILAMENTS switch is operated, the TRACK green light goes off.

a. The 120v input from the 30-second delay timer is applied to one terminal of the relay coil.

b. The TRACK FILAMENTS switch applies 120 volts to the other terminal of the relay coil.

c. A difference in potential no longer exists across the coil, and the relay deenergizes.

6. Show the students how to localize troubles in the green light circuits quickly.

INSTRUCTOR'S NOTE: A fairly accurate test, that will localize the trouble in two checks, is suggested below.

1. Ground 158 RC. If the light comes on, the trouble is in the line containing 158. If the light does not come on, the trouble is in the line above (on schematic) or the line below.

2. Check terminal No. 159 RC for 120 volts. If 120 volts are present, the trouble is in the lower string. If the voltage is missing, the trouble is in the lead containing the start relay.

3. The student should know that interchanging the two OFF lights is a simple check on the lamp itself.

SUGGESTED TROUBLES:

INSTRUCTOR'S NOTE: Caution students about the damage that can result if the regulator tube in the power supply is removed. Explain that the neon tubes will not function in the LOW VOLTAGE or OFF light circuits.

1. Primary.

   a. Misadjust the +450v power supply.

   b. Defective 393A in the +450v power supply.

   c. Defective 5687 in the 30-second delay timer.

   d. Remove one terminal of slide switch S12.

e. Remove one of the OFF light bulbs.

f. Remove terminal No. 158 RC.

g. Remove terminal No. 155 RC.

h. Open interlock in track blower motor.

i. Remove fuse F31 and the associated lamp (track filaments).

j. Remove the 15-minute delay timer.

k. Remove the ACQ trigger generator.

2. Review.

| |
|---|
| INSTRUCTOR'S NOTE: Each practical exercise contains a list of review activities. The review is designed to give the maximum of instruction to the students not engaged on the primary troubles. |

a. No review troubles will be placed in the equipment.

b. The students not engaged in troubleshooting should analyze the troubles by using the schematics.

c. Some time should be spent on component location.

# LESSON PLAN

## DELAY TIMERS AND POWER SUPPLIES (Part II)

OBJECTIVE: To explain the operation and repair of:

1. The +320v, +320v power supply,

2. The +250v series regulator, and

3. The +150v series regulator.

INTRODUCTION:

This lesson is a continuation of study on the power supplies used in the AAFCS M33. It is very important that the correct potentials be available. To insure that these potentials are constant, it is necessary to regulate the output of the power supplies. In the AAFCS M33, all power supplies which have a heavy work load or supply critical circuitry are regulated. In this lesson, additional power supplies will be studied, and the method of regulation in the AAFCS M33 will be discussed.

PRESENTATION:

1. The +320v, +320v Power Supply (fig 19-88).

   a. The function of rectifiers V10 and V11 is identical to that of the rectifiers in the +450v power supply.

      1) The major differences between the +320v and the +450v power supplies are the power transformer and minor changes in the driver circuit.

      2) Transformer T1 supplies 450 volts, each side of the center tap, to the plates of rectifiers V10 and V11.

         a) The amount of conduction for both tubes is controlled by the grid potential.

1. The dc control voltage is applied through the secondary winding of transformer T2.

2. Riding on the dc control voltage is an ac control signal supplied by transformer T2.

b) Filament voltage is supplied by transformer T3.

c) Once the grid has allowed the tube to conduct, the plate gains control.

d) L13, C14, and C17, a capacitive-input filter, smooths out the ripple.

3) Driver V12 controls the dc control voltage to the grids of V10 and V11.

a) Plate voltage for V12 is supplied by the full-wave crystal rectifier CR10 and CR11.

b) The action of V12 is dependent upon the voltage picked off the voltage divider in the grid circuit.

c) If the +320v output attempts to go more positive, the grid of V12 becomes more positive.

1. Tube current increases, and the plate voltage drops.

2. The drop in plate voltage is fed to the grids of V10 and V11 through the secondary of T2.

3. With a lower voltage on the grids, V10 and V11 decrease conduction.

4. The decreased conduction of V10 and V11 results in the output voltage's dropping back to +320 volts.

| INSTRUCTOR'S NOTE: Take students through the operation of a decrease in output and the adjustment of R22. |
|---|

b. Rectifiers V30 and V31 are identical in operation and circuitry to V10 and V11.

1) Driver V32 functions the same as driver V12.

2) Reference tube V33 does not function when the power supply is strapped to provide the +320v and +320v output.

| INSTRUCTOR'S NOTE: Explain strapping. |
|---|

c. The output of the +320v and +320v power supply is applied to the +250v series regulators.

2. The +250 v, +150v Series Regulator (fig 19-87).

a. It is much easier to understand the operation of the series regulator if it is throught of as simply a voltage divider composed of two resistors connected in series.

1) The voltage divider contains a fixed resistor grounded on one end and a variable resistor with one end tied to the positive supply.

2) The output is taken from the junction of the two resistors.

3) The desired output voltage can be obtained by varying the resistance of one resistor.

4) If the load changes, causing the output voltage to change, adjustment of the variable resistor brings the voltage back to its normal value.

5) The series regulator replaces the two resistors mentioned above and automatically adjusts the variable resistor whenever the output tends to change.

b. Tubes V1, V2, V3, and the associated circuitry for these tubes function as the fixed resistor and provide the automatic control for the section that replaces the variable resistor used in the above explanation.

1) The output of the regulator is taken from across the plate circuits of these stages and ground.

2) If the output voltage attempts to change, the change has its largest effect on the cathode of V1.

   a) Reference tube V2 maintains the voltage between the cathode and plate circuit of V1 at a constant potential.

   b) Any change in the output voltage therefore has to appear across the cathode resistors.

3) A change in the output also appears at the grid of V1.

   a) The grid does not control the tube because a much larger portion of the voltage change is felt at the cathode than at the grid. The cathode therefore controls tube conduction.

   b) The grid circuit should not be completely ignored because with different strapping the grid circuit does have control.

| INSTRUCTOR'S NOTE: Explain that this will be covered in more detail in the lesson on the -250v series regulator. |
|---|

4) If the output attempts to become more positive, the cathode of V1 also becomes more positive.

   a) With a rise in cathode potential, tube conduction decreases.

   b) The plate voltage of V1 increases as a result of the decreased conduction, and this increase in voltage is coupled to the grid of V3.

   c) Tube conduction increases, resulting in a drop in plate voltage, when the grid of V3 goes more positive.

d) The drop in plate voltage of V3 is applied to the grids of V4 and V5 causing the output of the regulator to return to normal (+250 volts).

c. Tubes V4 and V5, with their associated circuitry, form the section which replaces the variable resistor mentioned in the simplified regulator discussion.

1) The output of V3 is applied to the grids of V4 and V5.

2) The potential at the grids of V4 and V5 controls the conduction of these two tubes.

3) If the conduction of V4 and V5 decreases, the output of the regulator drops.

4) As explained before if the output of the regulator attempts to increase, the voltage applied to the grids of V4 and V5 decreases.

a) When the grids of V4 and V5 become more negative with respect to the cathode, tube conduction decreases.

b) The tube resistance has increased under these conditions, and more voltage is dropped across the two tubes.

c) Less voltage is supplied to the load since V4 and V5 are in series with the load.

d) The resistors in the cathode circuits of V4 and V5 serve as fuses in case of an overload and could be replaced with fuses without affecting circuit operation.

| |
|---|
| INSTRUCTOR'S NOTE: Relate information on the 47-ohm fuses. |

d. Regulator action when the output voltage attempts to <u>decrease</u>.

1) The drop in output voltage is felt immediately at the cathode of V1.

a) The drop in cathode voltage increases tube conduction.

b) The plate voltage drops because of the increased conduction.

c) The drop in plate voltage is coupled to the grid of V3.

2) As a result of the negative swing at the grid, V3 decreases conduction.

a) The plate voltage of V3 increases because of the decreased conduction.

b) The rise in plate voltage is applied to the grids of V4 and V5.

3) V4 and V5 increase conduction when the grid voltage increases.

a) As a result of the decreased tube resistance, less of the supply voltage is dropped across V4 and V5.

b) The regulator output voltage therefore increases to its normal value.

3. <u>The +150v Regulator (fig 19-86)</u>.

a. The +150v regulator and the +250v regulator are identical and interchangeable.

1) There are ten regulator chassis located in the radar cabinet just above the control panel.

2) The Jones plug connections (on frame of radar cabinet) are wired differently depending upon the use intended for the regulator.

3) Any of the regulator chassis may be used as a +250v, +150v, or a -250v regulator merely by plugging the chassis into the designated receptacle.

b. The +150v series regulator is identical in operation to the +250v series regulator.

1) The only difference between the two is the input voltage.

2) The +150v regulator has +220 volts applied and the +250v regulator has an input potential of +320 volts.

COMMON TROUBLES:

| | Symptoms | Probable Cause |
|---|---|---|
| 1. | Radar low-voltage check shows insufficient voltage. | Rectifier tubes and +320v supply not conducting or conducting very weakly.<br>Amplifier V1, in the series regulator, bad.<br>Reference tube V2, in the series regulator, bad. |
| 2. | Screens flicker and operation is erratic. | Power supplies overheating. (Open the doors to power supplies and regulators). |
| 3. | Voltage check shows no voltage output. | 47-ohm resistors open in one of the series regulators. |

INSTRUCTOR'S NOTE: Explain the method of finding a bad regulator. Caution the students not to pull out driver tube V12 or V32 while the set is on.

## PRACTICAL EXERCISE

### DELAY TIMERS AND POWER SUPPLIES
### (Part II)

AAFCS M33 SETUP: The equipment should be deenergized.

EQUIPMENT NECESSARY: Multimeter.

PRELIMINARY TROUBLE:

> INSTRUCTOR'S NOTE: The students should find the symptom and trouble while energizing the equipment.

1. Open low-voltage interlock.

2. Open interlock in barbette.

DEMONSTRATION:

1. Locate and give a brief explanation of the function of the following:

   a. The +320v, +320v power supply.

   b. The +250v series regulator, and

   c. The +150v series regulator.

2. Demonstrate the adjustment of the +320v, +320v power supply.

3. Each student will adjust the +320v, +320v power supply.

> INSTRUCTOR'S NOTE: The students can make adjustments on the computer power supplies. The operation of the computer power supplies will be covered in the computer portion of the course. Make sure that the students realize that it is not necessary to know the circuit operation when making field adjustments. Tell the students which power supplies are interchangeable.

4. Show the students the different strappings.

SUGGESTED TROUBLES:

1. Primary.

   a. Defective 6AU6 V1 in any series regulator.

   | INSTRUCTOR'S NOTE: Emphasize that the series regulators are identical and interchangeable. |
   |---|

   b. Misadjust the +320v power supply.

   c. Misadjust the +450v power supply.

   d. Place bad rectifier in the +320v power supply.

   | INSTRUCTOR'S NOTE: Caution students about removing the driver tubes V12 and V32. To prevent damage to the equipment, these tubes should be removed only when the low voltage is turned off. |
   |---|

2. Review.

   a. Have the students not engaged in clearing the primary troubles adjust the computer power supplies.

   b. Some time should be spent on clearing the system of troubles in the delay timer circuits.

   c. Explain the daily computer static tests to the group not working on primary troubles.

   d. Use any of the primary troubles listed in practical exercise 3, "Delay Timers and Power Supplies (Part I)."

# LESSON PLAN

## DELAY TIMERS AND POWER SUPPLIES
## (Part III)

OBJECTIVE:

1. To explain the location, operation, and repair of:

   a. The +220v and the +70v, -250v power supply, and

   b. The -250v series regulator.

2. To familiarize the student with the dc distribution system.

INTRODUCTION:

This conference concludes the study of the low-voltage power supplies associated with the ACQ and track radars. Those power supplies used with the computer will be presented during the computer portion of the course. In addition to the remaining power supplies used in the radars, the distribution of the dc power will be discussed. It is extremely important not only to know the operation of the supplies and regulators but also to be able to trace through the distribution circuits in order to locate, rapidly and efficiently, troubles originating in these units.

PRESENTATION:

1. The +220v and the +70v, -250v Power Supply (fig 19-89).

   a. The +220v Power Supply.

      1) The rectifier circuit used with this supply is identical to the +450v and the +320v power supplies.

         a) V10 and V11 form a full-wave rectifier.

         b) The power-supply output is controlled by varying the conduction of the rectifiers.

c) The rectifier conduction may be varied by adjusting the control voltage applied to the grids.

1. A dc voltage is applied to the grids through the center-tapped secondary of transformer T2.

2. Riding on the dc level is the ac control voltage.

2) Driver V12 controls the dc level of the signal applied to the grids of the rectifiers.

a) If the output voltage tends to rise, the grid of V12 swings in a positive direction.

1. Tube conduction increases.

2. The plate voltage drops, and the drop is coupled to the grids of the rectifiers.

3. The decreased grid voltage results in a drop of plate current, and the output voltage returns to its normal value.

b) If the output tends to drop, circuit action is the reverse of the above.

c) Resistor R22 is adjusted for the desired output level.

1. If the wiper arm of R22 is moved up to pin 1, the output voltage decreases.

2. If the wiper arm of R22 is moved down to pin 3, the output voltage increases.

| INSTRUCTOR'S NOTE: Explain action when the output level tends to drop. Go over field adjustment. Caution students not to remove driver tube V12 while radar is energized. |
|---|

b. <u>The +70v, -250v Power Supply.</u>

1) The +70v, -250v power supply develops 320 volts between its output terminals.

a) The power supply must be used with the -250v series regulator that supplies the ground reference point.

b) The reference point is placed in the circuit so that the 320v output is divided into two parts: 70 volts above ground and 250 volts below ground.

2) When studying the operation of this power supply, it is best to consider only the fact that 320 volts are desired between the output terminals.

a) V30 and V31 form a grid-controlled, full-wave rectifier circuit identical to those discussed previously.

1. If the grids of the rectifiers swing positive, the output voltage increases.

2. If the control voltage on the rectifiers swings in a negative direction, the output voltage decreases.

b) The A-section of driver V32 establishes the operating bias for the B-section.

1. The bias is developed by the tube current of the A-section flowing through the common cathode resistance.

2. The A-section sets the operating level of the B-section and has no further effect on the circuit.

3. The VR tube V33 in the grid circuit of V32A keeps the voltage between the cathode and grid constant.

4. V33 insures that the B-section will be provided with a steady fixed bias.

c) The B-section of V32 is the control tube for the rectifiers.

1. The conduction of the B-section is controlled by the bias supplied by the A-section and by the voltage picked off the voltage divider consisting of R41, R42, R43, and R44.

2. If the 320v output tends to rise, the grid of the B-section becomes more positive.

3. The plate voltage of V32B drops because of this increased conduction, and this drop is coupled to the grids of the rectifiers.

4. The rectifiers decrease conduction, and the voltage between the output terminals return to normal.

| |
|---|
| INSTRUCTOR'S NOTE: Explain the operation when the output attempts to decrease. Explain the field adjustment. |

5. The output voltage is applied to the -250v regulator.

2. The -250v Series Regulator (fig 19-85).

The regulator provides the ground reference point for the output of the +70v, -250v power supply.

| |
|---|
| INSTRUCTOR'S NOTE: Use a simplified introduction to this regulator as outlined below (diagram 1). |

a. The action of this regulator can easily be understood by replacing the components with two resistors.

1) When studying the +250v regulator, two resistors with the total voltage applied across the voltage divider and the output taken across the junction of the resistors were used.

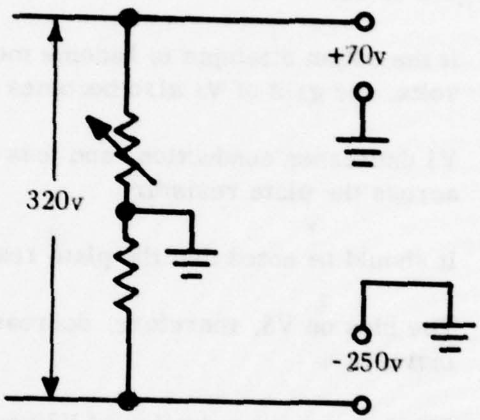



Diagram 1. The -250v regulator action.

2) In the -250v regulator, the same two resistors can be used but with the supply voltage applied across the two resistors and ground placed at the junction of the resistors.

3) Electrons flow up through the bottom resistor, the grounded junction, and the top resistor back to the supply (diagram 1).

4) The voltage across the bottom resistor is negative with respect to ground.

5) If the top resistor is variable and the supply voltage is 320 volts, the top resistor can be varied until 70 volts are dropped across it.

6) This leaves 250 volts dropped across the bottom resistor which is negative with respect to ground.

b. The -250v series regulator functions much like the +250v regulator, dropping +70 volts across one section and dropping -250 volts across the other section.

c. In this regulator, any output change has its greatest effect on the grid of V1.

1) If the output attempts to become more negative than -250 volts, the grid of V1 also becomes negative.

2) V1 decreases conduction, and less voltage is dropped across the plate resistor.

3) It should be noted that the plate resistor is tied to ground.

4) The bias on V3, therefore, decreases, and conduction increases.

5) The increased conduction of V3 results in a greater drop across the plate resistance.

6) The voltage drop across the plate resistance of V3 is the bias of V4 and V5.

7) As a result of the greater bias on the grids, the internal resistance of V4 and V5 increases, and a greater portion of the supply voltage is dropped across the two tubes.

8) Since less of the supply voltage remains to be dropped across the lower portion of the circuit, the output voltage returns to normal value.

| |
|---|
| INSTRUCTOR'S NOTE: Go over a condition where the output decreases. Also, cover the numbering of regulators and trouble-shooting by interchanging chassis. |

3. DC Distribution.

   a. The output distribution of the +450v power supply and +250v regulator is shown in figure 19-18.

   b. The +150v, A-distribution is shown on figure 19-31.

   c. The +150v, B-distribution is shown on figure 19-32.

   d. The +150v, C-distribution is shown on figure 19-34.

   e. The +250v, A- and B-distributions are shown on figure 19-23.

   f. The +250v, C- and D-distributions are shown on figure 19-24.

   g. The +250v, E-distribution is shown on figure 19-25.

   h. The +250v, F-distribution is shown on figure 19-26.

   i. The +270v, distribution is shown on figure 19-22.

   j. The +175v, distribution is shown on figure 19-22.

   k. The -28v distribution is shown on figures 19-35, 19-36, and 19-37.

COMMON TROUBLES:

| | Symptoms | Probable Cause |
|---|---|---|
| 1. | Scopes flickering. | Power supplies overheating. |
| 2. | Most supply voltages read incorrect. | Open 47-ohm resistors in the -250v series regulator. |

# PRACTICAL EXERCISE

## DELAY TIMERS AND POWER SUPPLIES
## (Part III)

AAFCS M33 SETUP: The equipment should be completely deenergized.

EQUIPMENT NECESSARY: Multimeter.

PRELIMINARY TROUBLES:

Misadjust the +320v power supply.

> INSTRUCTOR'S NOTE: The students should find the symptom and the trouble during the energizing procedure.

DEMONSTRATION:

1. Point out the location and give a brief explanation of the following:

   a. The +220v, +70v, and -250v power supply,

   b. The -250v series regulator, and the

   c. DC distribution terminal check points.

2. Remove V1 from the -250v regulator to demonstrate the importance of the -250v reference voltage.

> INSTRUCTOR'S NOTE: Be sure that each student has noted all the voltages and the changes indicated on the meter. Explain that the meter will indicate any change in the -250 voltage in the opposite direction. That is, for an increased output, the meter will show a decreased output, etc.

3. Demonstrate the adjustment of the +220v, +70v, and -250v power supply.

INSTRUCTOR'S NOTE: Each student should have an opportunity to make the field adjustment demonstrated.

4. Ground terminal No. 304 in the tracking console and have students watch for indications.

INSTRUCTOR'S NOTE: Fuse F44 will burn out when the TRACK FILAMENTS switch is operated.

5. Open terminal No. 74 in the radar cabinet and show the students the proper method of troubleshooting.

INSTRUCTOR'S NOTE: Indication will be no +320v output.

SUGGESTED TROUBLES:

1. Primary.

INSTRUCTOR'S NOTE: Caution students about removal of driver tubes in the power supply.

a. M1, the voltage-check meter, shorted across the terminals.

b. Defective rectifier in the +220v power supply.

c. Misadjust the -250v supply.

2. Review.

a. Use any of the primary troubles listed in practical exercises 3 and 4.

b. Students not troubleshooting should review chassis location.

c. Have students perform the daily checks on the computer.

d. Place a bad tube in one of the dc amplifiers in the computer.

| INSTRUCTOR'S NOTE: The student will be expected, wherever possible, to clear the trouble by changing chassis and changing tubes. |
| --- |

e. Check student knowledge of schematic symbols and ability to trace from one schematic to another.

# LESSON PLAN

## PULSE SYNCHRONIZER

OBJECTIVE: To present the operation and troubleshooting of the:

1. Pulse synchronizer,
2. Sync-pulse distribution, and
3. Preknock-pulse distribution.

INTRODUCTION:

Radar ranging in pulse-type radar is accomplished by measuring the time interval between the transmitted pulse and the return echo. The transmitter and range circuits must be started at the same instant for accurate range determination. Cathode-ray tubes are used to display the target video. The indicator sweeps must be started at the same time the transmitter fires. The pulse synchronizer is the source of the timing pulses for the transmitter, ranging, and sweep circuits of both radars.

PRESENTATION:

1. Synchronizer System (fig 2-1).

   a. The pulse synchronizer provides the following outputs:

      1) The sync pulse which occurs 5 microseconds after the preknock pulse and synchronizes both transmitters, and

      2) The preknock pulse which initiates the action of the range and sweep circuits just before the transmitters fire.

      3) A third output of the pulse synchronizer chassis is the test pulse used for alinement of the MTI system.

| |
|---|
| INSTRUCTOR'S NOTE: Explain that the test-pulse channel will be covered in the study of the MTI system. |

b. Pulse-Synchronizer Block Diagram Discussion.

1) Blocking oscillator V2 has an output frequency of 1, 000 pps when in autosync operation and approximately 930 pps when free-running.

2) The AUTO-INT switch must be in the AUTO position, and the MTI system must be on before the autosync pulse will be applied to the synchronizer.

3) The output of the blocking oscillator is applied to the grids of cathode followers V4 and V5.

4) Cathode followers V4 and V5 are normally cut off.

a) The strong positive pulse from the blocking oscillator overcomes the negative bias and allows the cathode followers to conduct.

b) The output of both cathode followers is developed across an inductance in each cathode circuit.

c) V4 and V5 are dual triodes connected in parallel to provide sufficient power for the output.

5) V4 is the preknock cathode follower.

a) The preknock pulse, taken from the cathode inductance, occurs at the same time as the output of the blocking oscillator.

b) The output of V4 is applied to the preknock distribution circuit.

6) V5 is the sync-pulse cathode follower.

   a) The pulse taken from the cathode circuit V5 is in time coincidence with the pulse at the cathode of V4.

   b) Stages V4 and V5 are identical circuits.

   c) The pulse taken from the cathode inductance of V5 is fed into a five-microsecond delay line.

   d) The output of the delay line, the sync-pulse, is applied to the sync-pulse distribution circuits.

| INSTRUCTOR'S NOTE: Tell students that capacitive coupling exists between the grid and cathode circuits of the cathode followers even when the plate circuits are open. |
|---|

c. Blocking Oscillator V2.

1) Blocking oscillator V2 is a dual triode connected in parallel.

2) V2 may be free running or synchronized by the autosync pulse.

| INSTRUCTOR'S NOTE: Cover the operation of V2 thoroughly. |
|---|

   a) The blocking oscillator is stable enough to provide satisfactory conditions when in the free-running mode of operation.

   b) The ranging circuits remain timed with the transmitter, even in the event of small deviations in the synchronizing frequency.

   c) The synchronizer must be extremely stable for proper MTI operation.

**INSTRUCTOR'S NOTE:** Stress the fact that there will be no autosync pulse applied to V2 unless the pulse synchronizer switch is in the AUTO position and there are no troubles in the MTI system. The MTI must be turned on.

3) Operation of blocking oscillator V2 in the free-running condition.

   a) When the low voltage is turned on, electrons flow through the tube and the plate inductance.

   b) A voltage is induced in the grid winding of the transformer which causes the grid to swing positive.

   c) The tube current further increases and amplifies the the pulse applied to the grid.

   d) This action continues until the tube is saturated.

   e) Meanwhile back at the capacitors in the grid circuit, C12, C4, and C5 charge because of grid current.

   f) The charge on the capacitors is negative on the grid side and positive on the cathode side.

   g) At tube saturation, the positive pulse on the grid disappears, and tube conduction decreases.

   h) The polarity across the plate winding of the transformer reverses, and a negative pulse is applied to the grid.

   i) The pulse on the grid adds to the charge on the capacitor, and the tube is cut off.

   j) The tube is held cut off by the charge on the capacitors in the grid circuit.

   k) V2 will stay cutoff until the capacitors discharge sufficiently to bring the grid potential to the conduction level.

l) The discharge path is through R12, R11, R6, R5, and the power supply.

m) When the tube is allowed to conduct, the operation is repeated.

n) The tube conduction builds up a sharp pulse across the cathode resistor.

o) The pulse across the cathode resistor is coupled by capacitors C9 and C10 to V4 and V5.

p) The repetition rate can be varied by adjusting R6 and switching to various points along the series resistance that is made up of R31, R7, R8, R9, and R10.

4) The blocking oscillator, when in autosync, will operate the same as when free running except that the repetition rate will be faster.

a) The autosync pulse, applied to the winding (pins 1 and 2), is negative.

b) The pulse is coupled to the grid winding which is wired to give polarity inversion.

c) The positive pulse at the grid overcomes the negative bias, and the tube goes into conduction.

d) Circuit action following the pulse is the same as for the free-running condition except that the next pulse triggers the tube before the capacitors have discharged to the conduction level of the tube.

d. <u>Preknock Cathode Follower V4.</u>

1) The positive pulse taken from the cathode circuit of V2 is coupled to the control grid of V4 through capacitor C9.

2) V4 is normally held cutoff by the negative bias developed across voltage divider R25 and R27.

3) The positive pulse at the grid of V4 raises the tube above cutoff.

4) As the grid voltage increases, the tube current increases.

5) A positive, 25v, 2-microsecond pulse is developed across the cathode inductance as a result of the increased tube current.

6) The output is fed directly to the coaxial preknock distribution circuit.

| INSTRUCTOR'S NOTE: Tell students about the plate resistor's opening and the signal's getting through the tube owing to capacitive coupling. |
|---|

e. Sync-Pulse Cathode Follower V5.

1) V5 is identical to V4.

2) Resistors R25 and R27 provide the cutoff bias for V5.

3) The pulse developed across the cathode inductance is applied to the five-microsecond delay line Z1.

4) The pulse at the cathode of V5 is in time coincidence with the pulse at the cathode of V4.

5) The output of the delay line, a 20v, positive pulse delayed five microseconds, is applied directly to the sync-pulse distribution circuit.

| INSTRUCTOR'S NOTE: Remind students that the pulse must have the correct amplitude in the equipment in order to function properly. |
|---|

2. Sync-Pulse Distribution.

The sync pulse is applied to:

a. The acquisition trigger generator through the arc-suppressor relay contacts,

b. The IFF unit, and

c. The track trigger generator.

3. Preknock-Pulse Distribution.

The preknock is applied to:

a. The carrier generator (where it is mixed with MTI video and later appears as the autosync pulse),

b. The switcher-mixer (to initiate the multivibrator or phantastron action for switching from MTI to bypass video),

c. The track range computer (as a timing reference),

d. The relay amplifier (as a timing reference),

e. The acquisition range unit ( to start the phantastron action),

f. The STC circuit (as a timing reference),

g. The tracking indicators (to start the sweeps), and

h. The plan-position and precision indicators (to start the sweeps).

SUMMARY:

The synchronizer provides a means of timing the transmitters, the range, and the indicator circuits of both radars. It would be impossible to integrate the two systems if they did not receive the same timing reference.

IA-6

COMMON TROUBLES:

| Symptoms | Probable Cause |
| --- | --- |
| 1. No sweeps on indicators. | Frayed shielding on the coaxial jack at the output of the synchronizer to the preknock distribution. |
| 2. No sweeps on indicators and abnormal operation of range circuits. | Open plate resistor in the preknock cathode-follower circuit V4. |
| 3. Transmitters do not fire or fire erratically. | Open plate resistor in the sync-pulse cathode-follower V5. |

# PRACTICAL EXERCISE

## PULSE SYNCHRONIZER

AAFCS M33 SETUP: The equipment should be completely deenergized.

EQUIPMENT NECESSARY: Multimeter, test amplifier, and synchroscope.

PRELIMINARY TROUBLE:

1. Misadjust one of the power supplies in the radar cabinet and one in the computer.

2. Open the low-voltage interlock.

3. Open one of the OFF light circuit interlocks.

| |
|---|
| INSTRUCTOR'S NOTE: Symptoms should be noticed by students as they energize the equipment. Have the students finding the symptoms locate and remove the trouble. |

DEMONSTRATION:

1. Point out and review the function of the following:

   a. The pulse synchronizer,

   b. Test amplifier,

   c. Test amplifier test-probe housing, and

   d. Sync- and preknock-distribution circuits.

2. Demonstrate the method used for calibration of the test amplifier.

| |
|---|
| INSTRUCTOR'S NOTE: Each student will calibrate the test amplifier. Be sure the student is aware of the importance of accurate calibration. |

3. Remove V2 from the pulse synchronizer.

| |
|---|
| INSTRUCTOR'S NOTE: Have students list all symptoms. Point out that by assembling all the symptoms synchronizer troubles are made very simple to find and to correct. |

4. Show the students how to adjust the pulse-repetition rate (prr).
5. Place a short in the preknock distribution and demonstrate procedure for removal.

| |
|---|
| INSTRUCTOR'S NOTE: Demonstrate the method of determining whether the trouble is a short in the distribution or if the pulse is not present at the output of the cathode follower. Remove the output jack. |

SUGGESTED TROUBLES:

1. Primary.

   a. Short terminals No. 1 and No. 2 of T4 in the synchronizer.

   b. Replace V2 with a bad tube.

   c. Replace V4 with a bad tube.

   d. Short the preknock test jack located under the control drawer of the tracking console.

   e. Open the cable which conveys sync pulse from the rf coupler to the modulator of the barbette.

2. Review.

   a. Have the students perform the daily checks on the computer.

   b. Misadjust the computer power supplies.

   c. Locate various chassis in the barbette and the tracking antenna.

> INSTRUCTOR'S NOTE: Caution the students not to place a tube with the grid pin clipped in either the sync or preknock-pulse cathode followers. This would remove the bias from the cathode followers and cause excessive plate current to flow, possibly burning up the plate resistor.

   d. If time permits, the instructor should place troubles from his own list in the equipment or use primary troubles from previous practical exercises.

> INSTRUCTOR'S NOTE: Be sure the students know the importance of gathering all the symptoms.

# LESSON PLAN

## TEST AMPLIFIER

**OBJECTIVE:**

1. To explain the operation, use, and troubleshooting of the test amplifier, and

2. To present troubleshooting procedures using the test amplifier.

**INTRODUCTION:**

The test amplifier is one of the most frequently used test instruments. Proper use of the test amplifier will save many hours of needless troubleshooting.

**PRESENTATION:**

1. Operation of the Test Amplifier (fig 19-91).

   a. The test amplifier is used with the track indicators as a built-in oscilloscope.

      1) The test probe, when not in use, is housed in the lower right door of the radar cabinet.

      2) The test amplifier is readied for use as follows:

         a) The test probe is removed from the door and plugged into the test-amplifier chassis,

         b) The test amplifier AMP ON-OFF switch is placed in the ON position, and

         c) The track video cable is removed from the OPERATE position and placed on TEST.

3) The stepped attenuator reduces the amplitude of the signal to prevent the video channel from being saturated.

4) The gain control provides a fine adjustment of the signal amplitude.

5) The CALIB ON-OFF switch applies plate and filament voltages to multivibrator V3.

a) The amplitude of the output signal of V3 is 10 volts peak-to-peak.

b) The output of V3, available at TP1, is used to calibrate the A-scopes.

c) Calibration of the test scope is important when testing circuits where a few volts difference in the signal strength may cause erratic operation.

| |
|---|
| INSTRUCTOR'S NOTE: Tell the students about some of the odd effects of a low preknock or sync pulse. |

b. The test probe contains a built-in, 20-db attenuator.

| |
|---|
| INSTRUCTOR'S NOTE: Tell the students that db is simply a measure of gain or loss and will be covered more completely later. |

1) The ground clip on the probe is seldom used in the field since the cable shielding is grounded at the test-amplifier connection.

2) If the probe becomes defective, the synchro-scope probe may be used with the test amplifier.

c. The stepped attenuator at the input to the test amplifier contains variable capacitors for frequency compensation.

d. V1 is a video amplifier.

1) L1 in the plate circuit provides high-frequency compensation.

2) R12 and C8A form a plate-decoupling network.

3) The variable cathode resistance controls the gain of the stage.

4) A fixed bias is developed by resistors R14 and R15.

e. Cathode follower V2 matches the high-output impedance of V1 to the low impedance of the coaxial cable.

1) The output is developed across cathode resistor R16.

2) R20 and C8B form a plate-decoupling network.

3) Fixed bias is supplied by resistors R14 and R15.

f. The output of the test amplifier is further amplified by the video amplifiers in each track indicator.

| |
|---|
| INSTRUCTOR'S NOTE: Tell the students that in troubleshooting the PPI or PI at the TCC, they may turn the RANGE indicator around so that the technician can use the test amplifier at the TCC. |

2. Calibration Multivibrator V3.

a. When the CALIB ON-OFF switch is placed in the ON position, V3 is supplied with plate and filament voltages.

b. V3 is a free-running multivibrator.

| |
|---|
| INSTRUCTOR'S NOTE: This is the first encounter with the free-running multivibrator in the equipment portion of the course. |

1) One of the sections of V3 will conduct slightly harder than the other when plate voltage is applied.

2) For the purpose of discussion, it will be assumed that the A-section starts conducting more then the B-section.

3) The plate voltage of V3A will drop because of the increased conduction.

4) The negative swing at the plate will be coupled to the grid of V3B through capacitor C12.

5) V3B will decrease conduction, and the plate voltage will increase.

6) The jump in plate voltage of the B-section will be coupled to the A-section through C11.

7) The A-section will conduct even harder and produce an increased drop in plate voltage.

8) The above action will continue until the A-section saturates, and the B-section is cut off.

9) C11 then builds up enough of a charge to decrease the conduction of the A-section.

10) The plate voltage of the A-section will increase, and this increase will be coupled to the grid of the B-section.

11) The B-section will start conducting, and the drop in plate voltage will be felt at the grid of the A-section.

12) The A-section will further decrease conduction, and circuit action will continue until V3A is cut off, and V3B is saturated.

13) The initiation of the next switching action depends on the RC charge of C12 and the discharge of C11.

c. CR1 clamps the output of the multivibrator at ground potential.

d. CR2 limits the positive output to 10 volts.

e. The 10v limit is established by voltage divider R28 and R29.

f. The calibration signal is monitored at TP1.

3. Troubleshooting with the Test Amplifier.

   a. The test amplifier can be set up for use very quickly.

   b. The sweeps of the indicators used with the test amplifier are synchronized with the rest of the radar.

   c. The test amplifier may be used to troubleshoot preknock troubles even though there is no sweep on the indicator.

      1) A dot will be present on the A-scope when the preknock is lost.

      2) When a test point where the preknock is present is monitored, the pulse appears at the position of the dot.

   d. The test amplifier is easily overdriven.

      1) Caution should be used to prevent this condition.

      2) The upper portion of the waveform will be clipped and will not appear on the indicator if the test amplifier is overdriven.

   e. The test amplifier may be used to troubleshoot in the barbette if the synchroscope is inoperative. This is accomplished by using the test video jack on the meter panel to bring the monitored signal into the van.

| INSTRUCTOR'S NOTE: Explain how this is accomplished. |
|---|

COMMON TROUBLES:

The test amplifier causes very little trouble in the field.

| Symptoms | Probable Cause |
|---|---|
| No signal appears on the A-scope when the test point is monitored. | Break in cable because sliding test amplifier rack has been pushed in with cable attached. |
| | An open in the probe end of the test cable. |

# PRACTICAL EXERCISE

## TEST AMPLIFIER

AAFCS M33 SETUP: The equipment should be completely deenergized.

EQUIPMENT NECESSARY: Multimeter, test amplifier, and synchroscope.

PRELIMINARY TROUBLE:

1. Open the low-voltage interlock.

2. Misadjust one of the power supplies.

> INSTRUCTOR'S NOTE: Symptoms should be noticed by students as they energize the equipment. Have students finding the symptoms locate and remove the trouble. The rest of the students should follow the trouble in the schematic diagrams.

DEMONSTRATION:

1. Select a student from the group and have him demonstrate the proper troubleshooting procedure for the test amplifier as you guide him through it.

2. The following is troubleshooting procedure for the test amplifier.

   a. Measure TP1 with the DC meter.

      1) The meter should read 4 to 5 volts.

      2) If voltage at TP1 is not 4 to 5 volts, check the plate voltage of V3 which should be 85 volts. If it checks out, continue with step 2b.

   b. If the signal is present at TP1, place a jumper from the junction of C13 and R27 to the grids of V2.

1) This will place a 100v peak signal on the grids.

2) If V2 is operating, a large deflection will be noticed on the track indicators.

c. The signal at TP1 can be used to check out the test probe, attenuator, and V1.

INSTRUCTOR'S NOTE: The students should be thoroughly familiar with the method of signal substitution. Tell them that signal substitution will be used in many other circuits throughout the course.

3. Have another student calibrate the test amplifier and monitor the following points on the pulse synchronizer.

a. Pin 4 of V2 (+100 to -60 volts).

b. Pin 3 of V2 (-50 volts).

c. Pin 8 of V2 (-90 volts).

d. Pin 7 of V4 and V5 (-85 volts).

e. Pin 6 of V4 and V5 (-75 volts).

INSTRUCTOR'S NOTE: The voltages are approximate and may vary slightly from system to system.

SUGGESTED TROUBLES:

1. Primary.

a. Open terminal No. 58 RC—no calibration signal.

b. Short R12 in the cathode circuit of V2 in the pulse synchronizer—no sync or preknock pulses.

c. Open terminal No. 71 RC—no sync or preknock pulses.

d. Short C6 in the attenuator of the test amplifier.

2. Review.

a. Misadjust one of the computer power supplies.

b. Place a bad tube in one of the dc amplifiers in the computer.

c. Much time should be utilized for component location.

d. Using spare chassis, have students trace out wirings.

INSTRUCTOR'S NOTE: *Be sure that the students know how to find the tube number from the underside of the chassis. They should also be able to find different pins on the Jones plugs.*

e. Have the students perform the daily checks on the computer.

# LESSON PLAN

## ACQUISITION RADAR FUNCTIONAL BLOCK DIAGRAM

OBJECTIVE:

The purpose of this lesson is to give the student an over-all picture of the function and location of the entire acquisition radar.

INTRODUCTION:

One of the advantages of the AAFCS M33 over older systems is its ability to continuously search even while tracking a target. The surrounding area is continuously scanned, providing the operators with a picture of all targets within the range of the system. It is the acquisition radar that provides the plan-position information of all targets within the limits of the system.

The acquisition radar is timed with the track radar because of the common sync and preknock pulses received from the pulse synchronizer (fig 1). This exacting time relationship, along with the target designator, makes integration of the two radars possible.

PRESENTATION:

1. Acquisition Radar, Simplified Block Diagram (fig 3).

   a. The timing pulses from the synchronizer initiate the action of the acquisition radar.

      1) The sync pulse is applied to the trigger generator.

      2) The preknock pulse is applied to the ranging and sweep circuits.

   b. The transmitter generates a high-power burst of rf energy.

      1) The peak power output is approximately one megawatt.

2) The pulse width is 1.3 microseconds.

3) The prf is 1,000 pulses per second when the system is in AUTO.

4) The frequency range of the acquisition magnetron is from 3,100 to 3,500 megacycles per second.

c. The rf system conveys the rf energy to the antenna where the energy is radiated. The return echo is picked up and fed to the receiver.

d. The receiver boosts the small return echo to a usable level.

1) The return signal is converted into an if signal.

2) Automatic frequency control is employed to maintain the intermediate frequency at 60 megacycles above the transmitter frequency.

3) The intermediate frequency is amplified and detected in the receiver system.

4) The moving-target indicator portion of the receiver allows only moving-target video to be displayed on the indicators.

e. The acquisition presentation system includes two plan-position indicators.

1) The resolver channel converts the mechanical rotation of the antenna into an electrical signal which is used to rotate the sweep on the PPI in synchronism with the antenna.

2) The PPI (when the switch is at 120,000) shows all targets in the surrounding area to a maximum range of 120,000 yards. The RANGE switch on the PPI may be operated to select the center 60,000-yard portion of the presentation.

f. The target designator provides a means of integrating the acquisition and track radars.

1) The designator produces the necessary marks and gates that are used to designate the target in aximuth and range and show the position of the track antenna in azimuth and range.

2) The precision indicator shows an enlarged view of a 5,000-yard by 30° segment PPI presentation.

2. Acquisition Radar Functional Block Diagram (fig 3-1).

a. Function and Use of the Transmitter.

1) The trigger generator, triggered by the sync pulse from the synchronizer, has an output pulse of sufficient amplitude to trigger the modulator.

2) The modulator at the time of the sync pulse allows the pulse-forming network to discharge through the pulse transformer.

3) The pulse transformer steps up the pulse, without polarity inversion, to an amplitude of from 38 to 45 kv.

4) The magnetron oscillates during pulse time and feeds the rf energy to the rf system.

b. Function of the RF System.

1) The waveguide couples the rf energy to the pillbox radiator.

2) The automatic frequency control (AFC) sampler couples a sample of the radiated pulse to the AFC mixer.

3) The ATR tubes prevent the return echo from being absorbed by the magnetron.

4) The TR tube prevents the transmitted pulse from saturating the receiver and damaging the crystals.

5) The directional coupler is used for making power, frequency, and standing-wave ratio measurements.

6) The rotary joint permits transfer of energy through the waveguide while the antenna is rotating.

7) The pillbox radiator forms the rf energy into a beam which is narrow in azimuth and broad in elevation.

8) The reflector lens focuses the beam and radiates the energy into space.

c. Function of the Receiver System.

1) The return echo is applied to the preselector which passes the desired frequency while attenuating all other freqencies.

2) The signal mixer mixes the return signal with the input from the local oscillator to produce the 60-megacycle if signal.

3) The intermediate frequency amplifier channel amplifies and detects the if signal.

a) The intermediate frequency preamplifier boosts the signal strength to overcome cable losses and establish a high signal-to-noise ratio.

1. The preamplifier consists of five stages of voltage amplification.

2. The first two stages are grounded grid amplifiers.

b) The attenuator compensates for gain variations in the receiver system.

1. As the set ages, the receiver gain will drop off.

2. Compensation for the reduced gain is made by reducing the amount of attenuation applied to the signal.

3. The attenuator is variable from 20 to 40 db in steps of 5 db.

c) The if amplifier has a gain of approximately 1, 000, 000 db.

1. The final stage of the if amplifier is a dual-diode detector which furnishes both positive and negative video at the output.

2. The positive video is applied to the MTI channel.

3. The negative bypass video is applied directly to the switcher-mixer.

4) The MTI system cancels video from stationary targets and passes moving-target video.

a) The MTI modulator channel modulates the 15-megacycle carrier with the video and the preknock pulse.

1. The 15-megacycle carrier is generated by a Hartley oscillator.

2. The output of the modulator channel is applied to the delay and nondelay channels.

b) The MTI delay channel delays the signal for 1, 000 microseconds.

1. The delay signal is detected at the output of the delay channel.

2. The video is negative and the preknock is positive at the output.

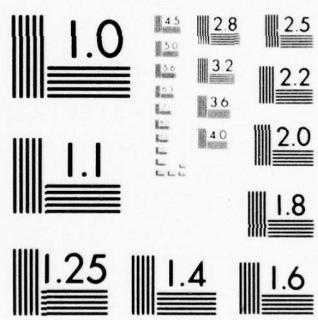
c) The nondelay channel attenuates and amplifies the signal by an amount equal to that received in the delay channel.

AD-A071 775 HUMAN RESOURCES RESEARCH ORGANIZATION ALEXANDRIA VA F/G 5/2
AAFCS M33 TECHNICIAN TRAINING PROGRAM. VOLUME III. ACQUISITION --ETC(U)
JUN 58 DA-49-106-QM-1

UNCLASSIFIED NL

2 OF 4

AD A071775




MICROCOPY RESOLUTION TEST CHART
NATIONAL BUREAU OF STANDARDS-1963-A

1. The nondelay signal is detected at the output of the nondelay channel.

2. The video is positive and the preknock is negative at the output of the nondelay channel.

d) The outputs of the delay and nondelay channels are compared in the MTI video channel.

1. Video returns from fixed targets will cancel at the input.

2. Moving-target video will not cancel and will be amplified by the video channel.

3. The negative, MTI video output is fed to the switcher-mixer.

e) The autosync channel also receives the output of the delay channel.

1. The positive preknock pulse is passed while the negative video is blocked by the first stage which is biased at cutoff.

2. The output of the autosync channel triggers the synchronizer.

5) The switcher-mixer selects either the MTI or bypass video for eventual application to the scopes.

a) Moving-target video may be displayed from 0 to 35, 000 yards. (On systems 726 and above the MTI range may be advanced to 120, 000 yards.)

b) Bypass video is presented at the end of the MTI display.

c) IFF information is mixed with the MTI and bypass video at the output of the switcher-mixer.

d) The output of the switcher-mixer is applied to the video-and-mark channel.

6) The video-and-mark channel mixes the video with the marks necessary for the complete PPI display.

7) The AFC unit tunes the local oscillator to a frequency 60 megacycles above the transmitter frequency.

8) The STC (sensitivity time control) reduces the receiver gain for close-in targets and reduces the blossoming effect at the center of the PPI's.

d. <u>Function of the Acquisition Presentation System.</u>

1) The acquisition-azimuth resolver provides an electrical signal which causes the PPI sweeps to rotate in synchronism with the antenna.

2) Each PPI tube has its own associated circuits for the amplification of the video and marks, the generation and amplification of sweep voltages, and the generation of unblanking voltages.

3) The sweep voltages are gated by the range gate produced in the video amplifier chassis, resulting in a sweep range of 60, 000 or 120, 000 yards.

e. <u>Target Designator.</u>

1) The precision indicators permit coordinated action between the acquisition and track radars.

a) The point about which the sector of display is centered depends upon the position of the associated TRACK ACQ switch.

<u>1</u>. When the switch is in the TRACK position, the display will be centered around the electronic cross.

2. When the switch is in the ACQ position, the display will be centered around the intersection of the range circle and the flashing azimuth line.

b) The video presented by the precision indicators is acquisition video.

2) The outputs of the ACQ range computer are the ACQ range mark and gate.

a) The ACQ range mark appears as the range circle.

b) The ACQ range gate unblanks the precision indicators for 5,000 yards range when the TRACK ACQ switch is in the ACQ position.

3) The resolver-channel outputs determine the position of the flashing and steady steerable-azimuth lines and the azimuth of the electronic cross.

4) The two mark generators.

a) The acquisition-mark generator has two outputs.

1. The acquisition-azimuth mark appears as the flashing azimuth line.

2. The acquisition-azimuth gate is used to unblank the precision indicators when the TRACK ACQ switch is in the ACQ position.

b) The track-mark generator is identical to, and interchangeable with, the acquisition-mark generator.

1. The track-azimuth mark appears as the radial line of the electronic cross.

2. The track-azimuth gate gates the ACQ track range mark to produce the arc of the electronic cross.

3. The track azimuth gate is also used for unblanking of the precision indicators when the TRACK ACQ switch is in the TRACK position.

5) Video-and-mark channel.

a) The azimuth marks and the track-azimuth gate from the mark generators, the range mark and gate from the ACQ range computer, and the ACQ track range mark and range gate from the track-range unit are combined in the mixer channel to produce the signals necessary for the PPI and precision indicator display.

b) The output of the mark-mixer channel is then combined with the acquisition video in the final stages of the video-and-mark channel and fed to the PPI and precision indicators.

# PRACTICAL EXERCISE

## ACQUISITION RADAR FUNCTIONAL BLOCK DIAGRAM

AAFCS M33 SETUP: The equipment should be completely deenergized.

EQUIPMENT NECESSARY: Test amplifier and synchroscope.

PRELIMINARY TROUBLES:

1. Replace V1 in any series regulator with a bad tube.

2. Replace V4 in the pulse synchronizer with a bad tube (do not clip grid pins of V4).

| INSTRUCTOR'S NOTE: Students should find symptoms and remove troubles during the energizing procedure. |
|---|

DEMONSTRATION:

1. The inputs and the outputs of the various chassis will be monitored during the exercise.

| INSTRUCTOR'S NOTE: While monitoring signals at each chassis, remove the output, and have the students note the symptoms. The students should know the proper readings for all meters. |
|---|

2. Locate and give a brief explanation of the following items.

   a. Acquisition Transmitter.

      1) Sync-pulse distribution out to the trigger generator.

      2) Input and output of the trigger generator.

      3) Grid of the modulator switch tube.

| |
|---|
| INSTRUCTOR'S NOTE: Caution students about the care to be taken to avoid injury from the high voltage in the circuit. |

4) CAPSULE VOLTAGE meter and adjustment.

5) AFC gate.

6) AFC sampler.

b. Acquisition Receiver.

1) Keep-alive voltage to the TR tube.

2) Local-oscillator power supply.

3) AFC and signal-mixer crystals and meter.

4) IF preamplifier.

5) AFC unit.

6) LPSA.

7) IF signal into the van and input to the if attenuator.

8) IF amplifier.

9) Switcher-mixer.

10) Video-and-mark mixer.

11) Video amplifiers on the PPI and precision indicator.

12) Follow the MTI signal from the if amplifier to the switcher-mixer.

SUGGESTED TROUBLES:

1. No troubles are recommended for this exercise.

2. Location, function, and measurement of the inputs and outputs of the different chassis should require the total time allotted.

# LESSON PLAN

## ACQUISITION TRANSMITTER
## (Part I)

**OBJECTIVE:**

To present the following:

1. Complete block diagram explanation of the transmitter,

2. Detailed operation of the trigger generator, and

3. Summary of the decibel and its use.

**INTRODUCTION:**

The purpose of the acquisition radar is to present an indication of all targets within 120,000 yards. A high-power burst of rf energy must be transmitted before return echoes can be received. It is the purpose of this lesson to provide a complete picture of the transmitter that generates the rf energy.

The performance of the transmitter must be checked periodically to maintain maximum efficiency. In radar, the decibel is used as a unit of measure for power and standing-wave ratio checks.

**PRESENTATION:**

1. Complete Block Diagram Explanation of the Acquisition Transmitter (fig 4-1).

   a. Trigger Generator.

      1) The positive sync pulse is amplified by amplifier V1A.

      2) Blocking oscillator V1B is triggered by the output of V1A.

a) The blocking oscillator generates a positive, 5-microsecond, 230v pulse.

b) The pulse is applied to the control grid of switch tube V2.

3) Thyratron switch tube V2 is normally cutoff.

a) V2 will conduct only when the pulse from the blocking oscillator is applied to the grid.

b) When V2 conducts, pulse-forming network Z1 is allowed to discharge through the primary of the pulse transformer.

4) Pulse-forming network Z1 charges to approximately twice the supply voltage.

5) The rapid discharge of Z1 through the primary of the pulse transformer results in a positive, 2-microsecond, 850v pulse at the secondary.

6) Tube V3 shunts any reflected energy to ground insuring that Z1 will always start charging from the same level.

b. The modulator operates on the same basic principle as the trigger generator.

1) Pulse-forming network Z6 charges to approximately twice the supply voltage because of the action of charging inductance L2.

2) Reverse-current thyratron V5 acts as a low-impedance path to ground for reflected energy resulting from an impedance mismatch.

3) Meter M1 permits the filament voltage of the hydrogen thyratron capsule, as well as the reverse current, to be monitored.

4) Hydrogen thyratron V4 acts as a switch to allow Z6 to discharge through the pulse transformer.

   a) There is an RLC network in the plate circuit of V4 which causes a step in the leading and trailing edges of the modulator-output pulse.

   b) To prevent arc-over in the magnetron cavity, the step shocks the magnetron into oscillation an instant before the full power is applied.

c. Pulse transformer T1 steps up the 1.3-microsecond pulse from the modulator to an amplitude of 38 to 45 kilovolts and applies it to the cathode of the magnetron.

d. Acquisition magnetron V1 has a rated peak power of 1 megawatt operating with a frequency range of 3,100 to 3,500 megacycles.

   1) Magnetron tuning drive motor B2 changes the magnetron frequency by moving tuning slugs in or out of the cavity.

   2) The meter in the lower right corner of the rf coupler in the barbette, as well as the meter on the control panel at the radar cabinet, indicates the average magnetron current.

e. The acquisition, high-voltage power supply provides the transmitter with four to eight kilovolts dc.

   1) The input to the power supply is 3-phase, 208v, 400-cycle power applied to saturable reactor L1.

   2) The saturable reactor, controlled by direct current, determines the amplitude of the ac applied to high-voltage transformer T1.

   3) The control current is obtained from selenium rectifier CR1 whose input is an ac voltage controlled by the acquisition HV ADJ variac.

4) The secondary of the high-voltage transformer delivers the three-phase alternating current to a three-phase, full-wave, bridge rectifier.

5) The rectifier develops the high potential required for proper operation of the modulator section.

2. Operation of the Trigger Generator (fig 4-2).

a. Sync-pulse amplifier V1A amplifies and inverts the positive sync pulse.

1) Resistor R6 matches the impedance of the coaxial line.

2) V1A conducts continuously.

3) When the sync pulse is applied, V1A increases conduction with a resulting drop in plate voltage.

4) The negative pulse at the plate of V1A is coupled through C4 to the plate of V1B.

5) Resistors R4 and R5 are the plate load.

b. Single-swing, blocking oscillator V1B is normally cutoff.

1) V1B is held cutoff by the negative voltage developed across voltage divider R1 and R2.

2) The negative input pulse causes a magnetic field to build up around winding 3-4 of T1.

3) The magnetic field cuts winding 1-2 and appears as a positive pulse at the grid of V1B thereby allowing V1B to conduct.

4) Tube V1B quickly saturates because of the regenerative action of the circuit.

5) When V1B reaches saturation, the lines of flux around winding 3-4 of T1 become stationary, and the grid of V1B goes negative.

| INSTRUCTOR'S NOTE: Explain that when V1B saturates, the voltage induced in windings 1-2 of T1 will disappear, and the grid will then feel the negative 27v from the junction of R1 and R2. |
|---|

6) The resulting decrease in plate current causes a negative voltage to be induced in the grid winding of T1 which results in V1B being cut off.

7) The output pulse is developed across winding 5-6 of T1 and applied to the grid of V2.

c. Hydrogen thyratron V2 functions as an electronic switch.

1) The grid controls the ionization of the thyratron gas within the tube.

2) The positive pulse at the grid of the switch tube causes the gas to ionize.

3) V2 when ionized allows pulse-forming network Z1 to discharge through pulse transformer T3.

4) V2 will cut off when Z1 has discharged.

d. Because of the action of inductance L1, pulse-forming network Z1 charges to approximately twice the supply voltage during the period between sync pulses.

1) A pulse-forming network is a combination of capacitance and inductance that is used to develop a high-voltage pulse.

2) The charge path of Z1 is from ground through the pulse transformer Z1 and through L1 to the power supply.

3) While Z1 is charging, L1 builds up a magnetic field.

4) When the charge on Z1 equals the supply voltage, current flow in the circuit tends to cease.

5) The field around L1 collapses causing current to continue in the same direction, and the charge on Z1 continues to build up.

6) Switch tube V2 allows Z1 to discharge when the potential across Z1 has attained its maximum value.

e. Pulse transformer T3 steps up and inverts the pulse that is developed across its primary when Z1 discharges.

f. Reverse-current diode V3 shorts any reverse current to ground.

| INSTRUCTOR'S NOTE: Briefly explain reverse current. |
|---|

1) A mismatch of the line and load impedance may cause a voltage of opposite polarity to appear across Z1 after the pulse.

2) The voltage reflected by this mismatch can build up to an amplitude high enough to break down the thyratron.

g. The output of the trigger generator may be monitored at TP2.

1) A comparison of the trigger pulse with the sync pulse will give an indication of the trigger-generator performance.

2) The trigger pulse is applied to the thyratron switch tube in the modulator.

3. The Decibel and Its Use in Radar Performance Checks.

| INSTRUCTOR'S NOTE: Tell the students that the term decibel will be used many times in radar. Give a few examples. The purpose of this lesson is to give the student only an idea of what is meant by the term decibel; not more than twenty minutes will be devoted to the explanation. |
|---|

a. The decibel (db) is the unit used to express power ratio.

b. The formula for computing the decibel gain or loss is:

$$db = 10 \log \frac{P1}{P2}$$

c. The power reading taken from the frequency power meter will be in milliwatts and is later converted to dbm or decibels above one milliwatt.

d. Table 2 illustrates one of the uses of the decibel.

Table 2

RADAR PERFORMANCE VERSUS RADAR RANGE

| db down for maximum over-all system performance. | Percentage of maximum range available. |
|---|---|
| -5db | 76 |
| -10db | 58 |
| -15db | 43 |
| -20db | 32 |
| -25db | 24 |

COMMON TROUBLES:

| | Symptoms | Probable Cause |
|---|---|---|
| 1. | Meter on the control panel at the radar cabinet indicates high voltage and no current for acquisition, high-voltage power supply. | Inductor L1/F13 open because of overheating. (Sets that are equipped with the fuze lamp in series with the inductance will need a replacement lamp.) |
| 2. | Acquisition transmitter indicates erratic operation. | Thyratron switch tube V2 not firing consistently. |

# PRACTICAL EXERCISE

## ACQUISITION TRANSMITTER
## (Part I)

AAFCS M33 SETUP: The equipment should be completely deenergized.

EQUIPMENT NECESSARY:

1. Multimeter,
2. Test amplifier,
3. Synchroscope, and
4. Frequency power meter TS ME-51.

PRELIMINARY TROUBLES:

1. Misadjust the +320v(B) power supply.
2. Replace V2 in the pulse synchronizer with a bad tube.

DEMONSTRATION:

1. Locate and review the function of the components of the acquisition trigger generator.
2. Calibrate the synchroscope.
3. Measure the amplitude of the trigger-generator output.

   INSTRUCTOR'S NOTE: Have each student set up, calibrate, and use the synchroscope in measurement of the trigger-generator output.

4. Replace V3 with a faulty tube.

INSTRUCTOR'S NOTE: Have the students notice the indications at the barbette and at the radar cabinet.

5. Demonstrate the use of the frequency power meter for frequency measurements.

INSTRUCTOR'NOTE: Each student should make the frequency measurement.

# LESSON PLAN

## ACQUISITION TRANSMITTER
## (Part II)

**OBJECTIVE:**

To present the detailed operation and troubleshooting procedures of the:

1. Acquisition modulator,
2. Acquisition magnetron and control circuits,
3. Acquisition-azimuth antenna drive, and the
4. Acquisition, high-voltage power supply.

**INTRODUCTION:**

The trigger generator develops a pulse with an amplitude sufficient to trigger the modulator. This lesson will show what happens as a result of that pulse.

**PRESENTATION:**

1. Acquisition modulator (fig 4-2).

   a. The operation of the modulator is much the same as that of the trigger generator.

   | INSTRUCTOR'S NOTE: Point out the similarity between the trigger generator and the modulator. |
   |---|

   b. Pulse-forming network Z6 is charged to approximately 12,000 volts between pulses. The charge builds up to approximately twice the input voltage supplied by the acquisition, high-voltage power supply.

1) The charge path for Z6 is up through the primary of the pulse former T1, through the charging choke, and back to the high-voltage power supply.

2) A magnetic field is built up around the charging choke while Z6 is charging.

3) When the charge on Z6 equals the supply voltage, the field around the charging choke collapses and current continues in the same direction.

4) The charge on Z6 will continue to build up until it is approximately twice the supply voltage.

5) The network is discharged at the maximum charge.

c. Hydrogen thyratron V4 contains a gas capsule which supplies hydrogen at the rate necessary to maintain a constant pressure in the tube.

1) The capsule filament voltage is adjusted by variac T2.

2) The trigger pulse is developed across R9 and applied through L1 to the grid of V4.

3) Inductor L1 isolates the trigger generator from the grid of V4 which swings highly positive when the gas ionizes.

4) When V4 starts to conduct, the current passes through the tank circuit of C2 and L3.

5) The circuit is shocked into oscillation for about one-quarter cycle. Further oscillation is damped by R18.

6) The output pulse of the modulator has a step in its leading and trailing edges because of the action of C2, L3, and R18.

7) The step in the leading edge of the pulse starts the magnetron oscillating before full power is applied.

8) The step prevents arc-over in the magnetron.

d. Reverse-current thyratron V5 prevents voltage build-up resulting from reverse current.

1) Excessive reverse energy could damage the circuit.

2) In case of excessive reverse current, relay K1 energizes and removes the high voltage.

3) With switch S2 in position 1, meter M1 reads the amount of reverse current.

Caution: The metallic base of the reverse current thyratron is connected to the pulse-forming network, and serious injury (possibly death) can result from touching the base while the high voltage is applied.

2. Operation of the magnetron and associated circuits (fig 4-4).

a. Pulse transformer T1 is located in the rf coupler of the acquisition-antenna assembly.

1) T1 is a step-up transformer with a 1:6 turns ratio.

2) The bifilar secondary windings are connected directly to the cathode of the magnetron.

3) There is no polarity inversion in the transformer.

b. Acquisition magnetron V1 is located in the rf coupler of the antenna assembly.

1) The magnetron operates the S-band over a frequency range of 3, 100 to 3, 500 megacycles.

2) The cathode of the magnetron receives the pulse while the anode is grounded.

3) The anode contains a number of resonant cavities.

4) The coupling bewteen the resonators is increased by conducting bars or straps which connect alternate anode segments.

5) The rf energy generated by the magnetron is coupled into the waveguide.

c. The magnetron tuning drive motor B2 can be controlled from the acquisition receiver control and the meter panel.

1) Motor B2 tunes the magnetron by changing the size of the resonant cavity.

2) A meter at the ACQ receiver control and a micrometer dial on the magnetron give relative indications of the frequency of operation.

d. The magnetron filament voltage is applied through the pulse-transformer secondary windings.

1) Filament voltage is applied to the magnetron when the acquisition power is turned on.

2) The heater current is adjusted by variac T4.

3) The heater current is monitored by meter M3 (fig 19-57).

4) Meter M3/F6 will not show heater current until the magnetron draws current.

5) Meters M3/A15 and M1/F6 (in position 1) show average magnetron current.

6) Tubes V6 through V9 provide a ground path for magnetron current in case the meter circuit opens.

7) When the magnetron draws sufficient current, relay K4/F7 energizes, allowing control of magnetron heater current and applying power to the receiver tuner motor.

3. The acquisition, high-voltage power supply provides dc power to the modulator to charge the pulse-forming network (fig 4-3).

a. Saturable reactor L1 receives a three-phase, 208v, 400-cycle input when the acquisition transmitter is turned on.

1) Both the ac and dc windings are wound on common iron cores.

2) If the direct current is increased, the stationary magnetic field increases.

3) The direct current can be increased until the magnetic field saturates the core.

4) When saturation is approached, the current through the ac windings produces very few lines of force.

5) Since there are, at saturation, very few lines of force produced by the ac windings, inductive reactance is minimum, and the amount of alternating current applied to T1 is maximum.

b. Selenium rectifier CR1 rectifies the ac input to provide the dc control current for the saturable reactor.

1) Rectifier CR1 is a bridge-type selenium rectifier.

2) Variac T1, adjusted by the ACQUISITION MIN MAX knob on the control panel, controls the amplitude of the ac applied to CR1.

3) By adjusting variac T1, the output amplitude of the high-voltage power supply is controlled.

Caution: A toxic gas is emitted from defective selenium rectifiers. Serious injury or death could result from overexposure.

c. The three-phase rectifier receives its input from the secondary windings of the delta-to-wye transformer T1.

1) During the part of the cycle that phase A is positive with respect to phase B, V1 and V4 conduct.

a) Electrons flow from the plate of V1 through V4, K1, and R4 up through R3, R2, R1, L2B, and L2A to the cathode of V1.

b) The output voltage is positive with respect to ground.

2) Electron flow, in all cases, follows the same path described in 1)a) with the exception of the tubes and secondary windings of T1.

a) When phase A is negative with respect to phase B, tubes V2 and V6 operate.

b) When phase B is positive with respect to phase C, tubes V2 and V5 operate.

c) When phase A is positive with respect to phase C, tubes V1 and V5 operate.

d) When phase A is negative with respect to phase C, tubes V3 and V6 operate.

3) Filtering is accomplished by L2A, L2B, C1A, and C1B.

4) Filament power is supplied by transformer T2 (fig 19-35).

a) Tubes V1, V2, and V3 are at the same dc potential and have a common filament winding.

b) Tubes V4, V5, and V6 are at different dc potentials and have separate filament windings.

d. Relay K1, spark gaps TY1 and TY2, and switch S1 are protective devices.

1) Relay K1 energizes when there is excessive current in the power supply and causes the ac input to the power supply to be removed.

2) Spark gaps TY1 and TY2 protect the current meter and the voltmeter, respectively, from damage by any sudden surge of current.

3) Switch S1 closes when the door to the power supply is opened and shorts the output to ground.

4. The ACQUISITION AZIMUTH SCAN switch at the tracking console does not have control of the antenna rotation unless the ACQUISITION AZIMUTH SCAN switch at the tactical-control console is in REMOTE.

a. When S13A/C13 is in position 1, ground is applied to the 10-rpm relay.

1) The -28 volts are removed from the 20- and 30-rpm relays.

2) Three-phase power is applied to the 10-rpm winding of B1/F1.

b. When S13A/C13 is in position 2, ground is applied to the 20-rpm relay.

1) When the 20-rpm relay is operated, -28 volts are removed from the 10-rpm winding.

2) Three-phase power is applied to the 20-rpm winding of B1/F1.

c. When S13A/C13 is in position 3, the 30-rpm relay operates.

1) The -28 volts are removed from the 10- and 20-rpm relays.

2) Three-phase power is applied to the 30-rpm winding of B1/F1.

d. The antenna drive SAFETY switch S1/F1 removes the -28 volts from the 10-, 20-, and 30-rpm relays.

e. Operation of S3A/B31 is identical to that of S13A/C13.

<u>SUMMARY:</u>

1. The modulator has a negative 4 to 6.5 kv output applied to the primary of the pulse transformer.

2. If the capsule voltage is too low, the modulator will not fire.

3. Excessive reverse current is a result of an impedance mismatch usually caused by a bad magnetron or a bad ATR or TR tube.

4. The pulse transformer steps up the pulse from the modulator and applies it to the magnetron.

5. The magnetron has a peak power output of one megawatt.

6. The magnetron frequency is changed by the magnetron tuning drive motor.

7. The tuning drive motor can be controlled from the meter panel or the ACQ control.

8) The high-voltage power supply provides a positive four to eight kilovolts to charge the pulse-forming network in the modulator.

COMMON TROUBLES:

| | Symptoms | Probable Cause |
|---|---|---|
| 1. | Transmitter will not fire. | Low capsule voltage. |
| 2. | Transmitter shows erratic operation. | Bad magnetron. |

INSTRUCTOR'S NOTE: Tell the students that the high-voltage dc cable to the modulator can be checked for high-voltage breakdown by disconnecting it at the barbette and then attempting to fire the transmitter. Go through the procedure for isolating a short to the modulator, cable, or high-voltage power supply.

# PRACTICAL EXERCISE

## ACQUISITION TRANSMITTER
## (Part II)

AAFCS M33 SETUP:

The equipment will be completely energized with the 15-minute delay timer ready for transmitter operation.

| INSTRUCTOR'S NOTE: This setup will give the students a chance to recognize normal operating conditions. |
|---|

EQUIPMENT NECESSARY:

1. Frequency power meter,
2. Synchroscope,
3. Multimeter,
4. Test amplifier, and
5. Acquisition power and frequency measurement forms.

PRELIMINARY TROUBLES:

1. No trouble will be inserted in the equipment because of the time needed to complete this lesson.
2. The students will perform the preoperational checks.

DEMONSTRATION:

1. Locate and give a brief explanation of the function of the following:
   a. The trigger generator,
   b. The modulator,

c. The pulse transformer,

d. The magnetron, and

e. The high-voltage power supply.

2. Demonstrate the method used for checking voltages in the high-voltage power supply.

> INSTRUCTOR'S NOTE: The multimeter should be used to perform the voltage checks in the high-voltage power supply. Caution must be used when making the checks. The variac should be turned fully CCW, and the meter should be connected before the high voltage is applied. The students should not touch the meter while the voltage is applied.

3. The adjustment and function of the capsule voltage will be explained.

a. Outline the causes of reverse current.

b. Demonstrate the method for checking the meter circuit.

4. Demonstrate the method of checking the high voltage at the plate of the modulator switch tube.

> INSTRUCTOR'S NOTE: The procedure outlined for checking out the high-voltage power supply will be followed when checking the modulator. Extreme caution will be used. The students must realize that the voltage can be checked easily without harm of injury if the proper procedure is followed. They must also realize that death can result from improper testing procedures.

5. Use frequency power meter to measure the power output.

> INSTRUCTOR'S NOTE: Each student will have an opportunity to make the power and standing-wave ratio measurements.

6. Have the students compute the power and standing-wave ratio using the forms provided.

7. Demonstrate the removal and replacement of the magnetron and the modulator switch tube.

> INSTRUCTOR'S NOTE: Split the class into two groups. Have one group remove and replace the magnetron while the other group is replacing the modulator switch tube. When both groups have finished, they will change positions and repeat the process.

SUGGESTED TROUBLES:

No troubles will be placed in the equipment. The entire period will be utilized for the activities listed above.

# LESSON PLAN

## ACQUISITION RF SYSTEM

**OBJECTIVE:**

To explain the function and operation of the:

1. Waveguide,
2. Duplexer,
3. Directional coupler,
4. Rotary joint,
5. Pillbox radiator,
6. Reflector, and
7. Elevation-coverage system.

**INTRODUCTION:**

The transmitter develops a high-power pulse of rf energy. To make use of the pulse, the rf system is employed to radiate the transmitter pulse and to receive and couple the return echo to the receiver. The rf system also provides a means of switching so that a single antenna can be used for transmission and reception. The elevation-coverage system will also be discussed in this lesson.

**PRESENTATION:**

1. Acquisition RF System Complete Block Diagram (fig 5-1).

   a. The waveguide delivers the rf energy to the antenna and couples the return echo to the receiver.

b. The duplexer is a switching device that includes the Y-junction, the TR tube, and two ATR tubes.

   1) During the period when the magnetron is operating, the TR tube prevents the rf energy from entering the receiver.

   2) The ATR tubes prevent the return echo from being absorbed by the magnetron.

c. The directional coupler samples a portion of the transmitted energy and makes it possible to measure power, frequency, and standing-wave ratio.

d. The rotary joint changes the shape of the waveguide from rectangular to circular and allows the antenna to rotate on a fixed base while maintaining electrical continuity during rotation.

e. The pillbox radiator focuses the beam and feeds it to the reflector.

f. The bar reflector forms the rf energy into either a needle or cosecant-squared pattern.

| |
|---|
| INSTRUCTOR'S NOTE: Show the students the difference between the patterns, and tell them that it is not important that they remember the names of the different patterns. It is important that they know what the pattern looks like for the various elevations. They should know what to do if a target in the midrange of the PPI display disappears. |

g. The elevation scan is changed by tilting the complete bar reflector and moving the injector bars in or out of the bar reflector.

   1) Power for tilting the bar reflector is furnished by a hydraulic system.

   2) The hydraulic system can physically tilt the reflector up to 9°.

3) Power is applied to the hydraulic pump motor upon application of the acquisition radar power so that pressure is kept up at all times.

4) The nose of the beam is tilted over a range of 20° (plus 2° to plus 22°) when the reflector is tilted over its range of 0° to plus 9°.

5) In automatic scanning, the beam traverses the 20° in approximately 20 seconds.

6) The ACQUISITION ELEVATION COVERAGE dials are calibrated in degrees and read from plus 2° to plus 20°.

7) A reading of 20° on the ACQUISITION ELEVATION COVERAGE dials corresponds to a beam elevation of 22°.

2. The Waveguide.

a. A rectangular waveguide is used to transfer the rf energy from the magnetron to the antenna and to return target information back to the receiver.

b. Arc-suppressor relay K5 is placed in the circuit to protect the magnetron in case of arc-over in the waveguide.

3. The Duplexer.

a. The use of a common antenna for transmitting and receiving requires a fast-acting switching device to disconnect the receiver during the transmitter pulse and to disconnect the magnetron during the period when signals may be received.

b. This switching device usually uses a TR tube and two ATR tubes.

c. The TR and ATR tubes are resonant cavities whose frequency corresponds to the transmitter frequency.

1) They are filled with gas at low pressure.

2) Spark gaps shorten the time for ionization of the TR tube and give maximum protection to the receiver.

3) The TR box is made up of three cavities separated by quarter-wavelengths.

4) The spark gap nearest the receiver has applied to it a keep-alive voltage of -800 volts.

5) Some of the energy from the transmitter enters the TR tube and causes it to fire.

6) The keep-alive voltage keeps the gas in the TR tube partially ionized so that it breaks down immediately when the rf energy from the magnetron enters the cavity.

7) The TR tube functions as a short across the waveguide at the receiver input section of the Y-junction, and, as a result, the transmitter energy has a high impedance toward the receiver section and a matched impedance toward the antenna.

8) Two ATR tubes are used to insure broad band operation.

| INSTRUCTOR'S NOTE: Tell the students about field troubles with the TR and ATR tubes. |
| --- |

d. Received signals enter the waveguide at the pillbox radiator and travel down the waveguide to the Y-junction.

1) The received signal does not have enough energy to ionize the TR or ATR tubes.

2) The ATR tubes act as an open line, and no energy enters the magnetron.

3) The TR tube presents a low-impedance path for the received energy where the signals see a matched line.

4) As a result, the maximum received signal strength is delivered to the signal mixer.

4. The Directional Coupler.

a. The acquisition directional coupler is a bidirectional coupler that samples the rf output and provides a means for measuring frequency, power output, and standing-wave ratio.

b. Energy is fed into the directional coupler by three coupling irises.

c. Two pickup points are located within the coupler.

1) A pickup probe is inserted in the directional coupler on the right side to measure power and frequency.

2) A probe made of power-absorbing material is inserted on the left side.

3) The absorbing material is used to dissipate unwanted energy in order to prevent erroneous indications on the power-measuring device.

4) The positions of the two probes are reversed when measuring reflected power.

5. The Rotary Joint.

a. To transfer power from a fixed base to a rotating antenna, a rotating joint is used.

b. The rotary joint provides for mechanical and electrical continuity during antenna rotation.

c. Energy is fed from the rectangular waveguide to a circular coaxial transmission line.

d. Energy may be coupled out of the coaxial line into the waveguide without regard to the angle between the waveguide and the coaxial transmission line.

e. When the energy has passed through the rotary joint, it leaves the coaxial line and enters the waveguide leading to the pillbox radiator.

f. Later systems are equipped with pressurized waveguide to prevent arcing.

1) It is not necessary to use the compressor at all times.

2) Should arcing occur in the waveguide, the arcing may be reduced or eliminated by turning the compressor on.

6. The Pillbox Radiator.

a. The pillbox contains a cavity that focuses the rf energy into a narrow beam in the horizontal plane.

b. The waveguide feeding the pillbox is offset from center.

| INSTRUCTOR'S NOTE: The waveguide is offset because energy losses occurred as a result of standing waves when energy was fed into the cavity at the exact focal point during original production tests. |
|---|

c. The energy leaving the waveguide spreads over a broad area toward the parabolically curved, narrow wall which is located directly below the bar reflector.

1) The rf energy is formed into a straight-plane phase front by the parabolically curved wall and directed toward the front of the pillbox.

2) A tilted flat flap reflects the rf energy up into the bar reflector.

| INSTRUCTOR'S NOTE: Illustrate the energy flow through the antenna. |
|---|

7. The Bar Reflector.

a. The reflector is a grating made up of many evenly spaced bars.

b. In the lower portion of the reflector, there is an auxiliary grating of separately mounted bars situated within the spaces between the bars of the main reflector grating.

c. The spread of the beam radiated from the bar reflector is large in elevation but narrow in azimuth.

d. The beam pattern will change as the reflector is tilted and the auxiliary reflector is injected or retracted.

e. The technician, as well as the operator, should know the beam patterns for the various scan conditions.

f. The scan condition is changed by making two adjustments at the hydraulic control unit of the antenna.

1) One adjustment governs the point at which the auxiliary reflector grating is injected.

2) The second adjustment sets the upper limit of automatic scan.

3) It is possible to override the upper limit for automatic operation by means of the ACQUISITION ELEVATION SCAN switch and to scan manually between the extreme limits.

4) The beam has a pencil pattern when the auxiliary reflector bars are retracted.

5) The beam has a cosecant pattern when the auxiliary bars are injected.

| |
|---|
| INSTRUCTOR'S NOTE: Tell the students that the beam pattern is changing during the injection of the auxiliary grating. |

g. There are a number of scan modes possible; four of these modes cover the complete range of operation.

1) Scan condition 1.

a) In automatic scanning, the beam will traverse between 2° and 22°.

b) The beam has a pencil pattern at 2°.

c) The bar injection begins at 2° and is complete at 6°.

d) The beam remains in a cosecant pattern from 6° to the upper limit.

2) Scan condition 2.

a) The beam will traverse between 2° and 13° in automatic scan.

b) The beam will have a pencil pattern from 2° to 6° at which time the bar injection begins.

c) The change to a cosecant beam pattern is complete at 10°.

d) The beam retains the cosecant pattern to the upper limit.

3) Scan condition 3.

a) In automatic scan, coverage is between 2° and 17°.

b) The beam has a pencil pattern up to 10° at which point the auxiliary bar injection begins.

c) The injection is complete at 14°.

d) The beam is cosecant in pattern from 14° to 17°.

4) Scan condition 4.

a) In automatic scan, the beam covers the entire range from 2° to 22°.

b) Bar injection begins at 14°.

c) Bar injection is complete at 18°.

INSTRUCTOR'S NOTE: Show the students what the pattern looks like at the limits and change-over points for each scan mode, and cover the adjustments for various scan modes. Tell the students that targets may not be visible at the upper limits. Avoid discussion of trigonometry.

h. Scan condition 2 is the preferred mode of operation.

i. The factory adjusts every antenna sent into the field for scan condition 2.

8. The Hydraulic Control System.

a. A motor-driven pump and various control valves are contained in the hydraulic control unit which is located in the lower rear center section of the antenna just below the pillbox.

b. Hydraulic cylinders control the tilting and auxiliary grating injection.

c. The two hydraulic valves up and down are operated by solenoids.

d. The ACQUISITION AZIMUTH SCAN switch must be in one of the three speed positions before elevation scanning is possible.

e. When one of the ACQUISITION ELEVATION SCAN switches is placed in the UP position, a ground is applied to one side of the up solenoid.

f. As the upper limit is reached, the scan stops and remains in position.

g. Automatic scan will occur when one of the ACQUISITION ELEVATION SCAN switches is in the DOWN position.

h. When one of the ACQUISITION ELEVATION SCAN switches is placed in the DOWN position, a ground is applied to the down solenoid through contacts 1 and 3 of K1/F15.

1) When the lower limit is reached, the lower-limit switch operates applying ground to K1/F15.

2) The K1/F15 operates and is held energized through its own contacts 4 and 5 and contacts A and C of the upper-limit switch.

3) Ground is applied, through contacts 2 and 3 of K1/F15, to the up solenoid.

4) The down solenoid is released when contacts 1 and 3 of K1/F15 open.

5) At the upper limit, S1 opens releasing K1/F15 and the up solenoid.

6) The down solenoid is energized through contacts 1 and 3 of K1/F15, and the circuit continues to scan between the two limit switches.

i. JOGGING switch S3 is located on the hydraulic control unit.

1) Switch S3 is a grounding control for the up and down solenoids.

2) It provides elevation scan without azimuth scan and enables the operator to check the mechanical functioning of the reflector.

9. <u>Operation of the Hydraulic System.</u>

a. When acquisition power is applied, the pump develops low pressure in the line.

1) Pressure is applied through the relief valve and the fitting assembly to the solenoid valve.

2) With L1A and L1B deenergized, fluid flows from P to R (fig 19-97) and back to the reservoir.

b. Operation with the up solenoid energized.

1) Fluid no longer flows from P to R, and pressure builds up.

2) This pressure is applied to the relief valve where any excess above 250 pounds per square inch is bypassed to the return line.

3) The pressure line continues to the distribution assembly.

4) Pressure is applied to the brakes releasing them.

5) With the up solenoid energized, the valve will move in the associated direction, and pressure will be applied to the primary actuator.

6) The check valves regulate the flow of fluid in the pressure lines to the primary actuator.

7) Pressure is applied to the actuator piston which moves to tilt the reflector up.

8) The action for the follow-up valve assembly is the same for the secondary actuator except that no check valves are needed for the lighter reflector grating.

c. The complete process is reversed when the down solenoid is operated.

d. To prevent erratic operation, air must be kept out of the hydraulic lines.

IA-11

SUMMARY:

1. The waveguide conveys the rf energy to the antenna when the transmitter is operating and brings target returns to the receiver.

2. The TR and ATR tubes allow one antenna system to be used for both transmission and reception.

3. The directional coupler provides a means for measuring power, frequency, and standing-wave ratio.

4. The rotary joint maintains electrical and mechanical continuity during antenna rotation.

5. The pillbox radiator focuses the beam narrow in azimuth and broad in elevation.

6. Elevation scanning is accomplished by tilting the bar reflector.

7. The beam pattern is changed by injecting the auxiliary reflector.

8. Power for tilting the bar reflector and injecting the auxiliary grating is furnished by the hydraulic system.

9. Automatic elevation scanning is possible only with the ACQUISITION ELEVATION SCAN switch in the DOWN position.

COMMON TROUBLES:

| | Symptoms | Probable Cause |
|---|---|---|
| 1. | Arcing in the barbette. | Bad TR or ATR. |
| 2. | Meter for transmitter high voltage, located on the control panel, indicates erratic transmitter operation. | Bad ATR. |
| 3. | Reflector will not tilt when ACQUISITION ELEVATION SCAN switch is operated. | Defective hydraulic system; call ordnance. |

# PRACTICAL EXERCISE

## ACQUISITION RF SYSTEM

AAFCS M33 SETUP: The equipment will be completely deenergized.

EQUIPMENT NECESSARY:

1. Multimeter,
2. Synchroscope, and
3. Frequency power meter.

PRELIMINARY TROUBLES:

1. Lower the capsule voltage.
2. Turn the ACQ blower motors OFF.

> INSTRUCTOR'S NOTE: The students will energize the equipment. They should find the symptoms and correct the malfunctions during the energizing procedure.

DEMONSTRATION:

1. Locate and give a brief explanation of the function of the following:

   a. The waveguide,

   b. TR and ATR tubes,

   c. Rotating joint,

   d. Antenna (pillbox radiator, bar reflector, etc.),

   e. Hydraulic system,

f. Arc-suppressor relay circuit,

g. Elevation-scan control circuits, and

h. Azimuth drive.

2. Demonstrate the proper method of changing the scan mode of the elevation-coverage system.

3. The remaining time should be used for making frequency, power, and standing-wave ratio measurements.

# LESSON PLAN

## ACQUISITION RECEIVER FUNCTIONAL BLOCK DIAGRAM

### OBJECTIVE:

To explain the function of the acquisition receiver on a block-diagram level.

### INTRODUCTION:

The synchronizer, as previously studied, generates pulses which are used to time the transmitter and the ranging circuits. The transmitter develops a high-power pulse of rf energy. The receiver converts the return echo into usable information. From this lesson the student should gain an over-all picture of the function and operation of the receiver on a block-diagram level. Circuitry of the receiver will be covered in future lessons.

### PRESENTATION:

1. Acquisition Receiver System Simplified Block Diagram (fig 6).

   a. The mixer channel mixes the rf echo with the local-oscillator output to produce the if signal.

   b. The local oscillator generates a cw signal at a frequency 60 megacycles above the magnetron frequency.

   c. The local-oscillator power supply provides the keep-alive voltage to the TR tube, dc voltages to the local oscillator, and filament voltage for the local oscillator, AFC unit, and the if preamplifier.

   d. The if preamplifier boosts the signal strength to overcome cable losses and provide a high signal-to-noise ratio.

   e. The if attenuator compensates for the gain variations resulting from aging receiver components.

f. The if amplifier channel amplifies the if signal and develops both positive MTI and negative bypass video.

g. The MTI modulator channel generates a 15-mc carrier which is modulated by the MTI video and the preknock pulse.

h. The nondelay channel attenuates the input from the MTI modulator by an amount equal to the attenuation of the delay cell. The signal is amplified, detected, and sent to the MTI video channel.

i. Video from the MTI modulator is also applied to the delay channel where it passes through the 1,000-microsecond delay cell.

1) The signal is then amplified and detected in a manner almost identical to that in the nondelay channel.

2) The output is sent to the MTI video channel and the autosync channel.

j. The autosync channel eliminates the negative, delay video and passes the positive, preknock pulse which is shaped and sent to the synchronizer as the autosync pulse.

k. The MTI video channel compares the negative, delay video with the positive, nondelay video.

1) Echoes from fixed targets will almost or completely cancel.

2) Signals from moving targets will vary in amplitude and time relationship and appear at the output as negative MTI video.

3) The output is applied to the switcher-mixer.

l. The switcher-mixer selects either MTI or bypass video.

1) The MTI video is replaced by bypass video at a range determined by the operator.

2) The IFF information is mixed with the video and may appear at any time regardless of the type of target video.

3) The negative output is applied to the video-and-mark channel.

m. The video-and-mark channel mixes the video and marks which are sent as a composite signal to the PPI and precision indicators.

n. The AFC channel provides continuous frequency correction for the preselector and local oscillator thereby maintaining the 60-megacycle intermediate frequency.

o. The sensitivity time control lowers the amplitude of strong nearby signals while allowing maximum amplification for distant target echoes.

2. Acquisition Receiver Complete Block Diagram (figs 6-1 and 6-2).

a. Mixer Channel.

1) The preselector presents a low-impedance path to the transmitter frequency and attenuates all other frequencies.

a) There is maximum attenuation at the image frequency.

b) The preselector is a cylindrical resonant cavity tunable over the entire frequency range of the magnetron.

2) The signal mixer mixes the local-oscillator output with the return echo and extracts the intermediate frequency.

a) The rf echo is fed into the mixer by a matching iris in the waveguide.

b) Local-oscillator energy is introduced by coaxial cable.

c) Crystal CR2 detects the signal.

d) A concentric, polyiron core acts as an rf choke to filter the rf energy.

b. Local Oscillator.

1) The local oscillator is a reflex klystron with an external resonant cavity.

2) It is tuned by varying the physical size of the resonant cavity and the negative repeller-plate voltage.

3) The output is fed to the signal mixer and the AFC mixer.

c. Local-Oscillator Power Supply.

1) It is located at the right rear of the acquisition rf coupler.

2) It uses a conventional full-wave rectifier.

3) Tubes V2 through V7 regulate the output voltages.

4) The output voltages are:

a) A -800v direct current for use as keep-alive voltage for the TR tube,

b) A -625 volts and -400 volts for use as repeller-plate voltage for the local-oscillator tube,

c) A -325 volts to the cathode of the local oscillator, and

d) A 6.3v alternating current to the local-oscillator tube, AFC unit, and if preamplifier for filament voltage.

d. The IF Preamplifier.

1) It is mounted at the right side of the tuning-drive gear box in the acquisition rf coupler.

2) The first two stages are grounded-grid triode amplifiers to reduce noise.

3) The final three stages are high-gain pentode amplifiers which are transformer coupled.

4) The if preamplifier is given a broad bandpass by loading resistors across the coupling transformers.

5) The output is coupled by coaxial cable to the if attenuator.

e. The IF Attenuator.

1) It matches the 75-ohm impedance of the cable from the if preamplifier.

2) Attenuation is variable from 20 decibels to 40 decibels in steps of 5 decibels.

f. The IF Amplifier Channel.

1) The first six stages are medium-gain circuits employing back bias to prevent overloading as a result of strong signals.

2) The back bias reduces clutter on the PPI's and is one of the antijam features of the receiver.

3) Broad-tuned transformers couple the signal between stages.

4) The seventh stage is a high-gain power amplifier.

5) The final stage is a dual diode which detects the signal to produce the negative bypass and positive, MTI video.

g. The MTI Modulator Channel.

1) It receives the positive, MTI video and the preknock pulse.

2) The test pulse is used to aline the MTI circuits, and it does not enter the modulator channel under normal operating conditions.

3) A 15-megacycle carrier is generated and modulated by the positive, MTI video and the negative preknock pulse.

4) The output is fed to the MTI delay and nondelay channels.

h. Nondelay Channel.

1) Video from the MTI modulator undergoes approximately 65 decibels of attenuation.

2) The signal is then amplified by four stages of voltage amplification and one stage of power amplification.

3) Crystals CR1 and CR2 detect the output.

4) The output rides at a positive four-volt level.

a) The output level is equal in amplitude and opposite in polarity to the output level of the delay channel.

b) Should a difference occur between the two levels, a voltage is fed through the nondelay AGC amplifier to vary the gain of the nondelay channel so that the two dc levels are equal.

i. Delay Channel.

1) The delay line delays the signal from the MTI modulator channel 1, 000 microseconds; a 60 db attenuation is experienced by the signal.

2) The signal is amplified and fed through a cathode follower, for impedance matching purposes, to the 0- to 20-decibel attenuator.

3) The 0- to 20-decibel attenuator provides a means for keeping the output amplitude of the delay and nondelay channels equal.

4) The signal then undergoes four stages of voltage amplification followed by one stage of power amplification.

5) Crystals CR1 and CR2 detect the signal and the output, riding at a negative four-volt level, fed to the autosync pulse channel and delay line Z1.

a) Delay line Z1 provides a means for adjusting the time relationship of the signal from the delay and nondelay channels.

b) Should the four-volt level change, the output of the delay AGC amplifier causes the gain of the delay amplifier to change so that the four-volt level is maintained.

j. Autosync Channel.

1) The negative video is eliminated, and the positive preknock pulse is passed through the channel.

2) Three stages are used to shape the pulse.

3) The output is the autosync pulse that triggers the synchronizer so that action in the transmitter and sweep circuits is initiated at concurrent intervals.

k. The MTI Video Channel.

1) Delay and nondelay video are compared across a resistive network at the input.

2) Echoes from fixed targets cancel while moving-target video does not cancel.

3) The circuit is arranged so that the output will always be negative.

4) The negative, MTI video is sent to the switcher-mixer channel.

l. Switcher-Mixer Channel.

1) It receives as inputs the preknock pulse, bypass video, MTI video, and IFF video.

2) The preknock pulse starts a multivibrator the output of which gates the switch tubes and allows either MTI or bypass video to appear on the PPI's.

| |
|---|
| INSTRUCTOR'S NOTE: Inform the students that on systems 726 and above, the multivibrator has been replaced by a phantastron. |

3) The range of the MTI presentation is dependent on the bias of the multivibrator which is controlled by the operator.

a) When the multivibrator tubes reverse operation, MTI video is replaced by bypass video.

b) The MTI switch in the OFF position removes the bias voltage to the multivibrator rendering it inoperative, and only bypass video appears on the PPI's.

4) The IFF information is mixed with the video at the output of the switcher-mixer.

5) The output video is sent to the video-and-mark channel.

m. Video-and-Mark Channel.

1) The positive, video input passes through one stage of amplification where it is inverted.

2) The video and marks are mixed at the input network to the final stage.

3) The output is sent to the PPI and precision indicators each of which includes its own video amplifier.

n. <u>The AFC Channel.</u>

1) The AFC mixes the local-oscillator output with a sample of the transmitted pulse to produce an intermediate frequency.

2) Should the intermediate frequency deviate from 60 megacycles, a voltage is developed that causes the tuning motor to drive and alter the local-oscillator frequency so that the intermediate frequency returns to 60 megacycles.

a) When a change in frequency occurrs, the discriminator develops a series of pulses at its output.

b) The pulse stretcher receives the pulses and converts them to a dc voltage.

c) The dc voltage is fed to the modulator which has a 400-cycle output when a dc input is received.

d) The phase and amplitude of the 400-cycle output correspond to the polarity and magnitude of the dc input.

e) The 400-cycle voltage, amplified by the LPSA, causes the tuning motor to turn in a direction determined by the phase of the signal.

3) If the intermediate frequency is out of the bandpass of the if amplifier, the autosearch circuits take control.

a) Relay circuits apply a dc voltage to the modulator and cause the local oscillator to tune through its frequency range.

b) With the dc voltage applied to the modulator, circuit action is the same as for slight frequency variations.

o. <u>The STC Channel.</u>

1) The preknock input initiates the action of multivibrator V1.

2) The multivibrator output is applied through cathode follower V2A, and CR4 and CR1, to cathode follower V3A.

3) A capacitor in the input circuit to V3A causes the pulse to have a sloping trailing edge.

4) The signal is amplified by V2B and presented to cathode follower V3B.

5) The output of V3B, a negative waveshape riding on a dc level determined by the acquisition receiver gain control, is delivered to the last three stages of the if preamplifier.

SUMMARY:

1. The intermediate frequency of the acquisition receiver system is 60 megacycles.
2. The if amplifier produces bypass and MTI video.
3. The 15-megacycle carrier, produced in the MTI modulator channel, is used to carry the MTI video through the 1,000-microsecond delay line.
4. The MTI video channel compares delay and nondelay video to yield an output from which fixed-target video has been eliminated.
5. The switcher-mixer mixes IFF information with either MTI or bypass video.
6. Continuous frequency compensation is provided by the AFC channel.
7. The STC channel allows reduced gain for close-in target echoes.

## PRACTICAL EXERCISE

## ACQUISITION RECEIVER FUNCTIONAL BLOCK DIAGRAM

AAFCS M33 SETUP: The equipment will be completely deenergized.

EQUIPMENT NECESSARY: Test amplifier, multimeter, and synchroscope.

PRELIMINARY TROUBLES:

1. Open interlock in track or ACQ green-light circuit.

2. Lower capsule voltage.

> INSTRUCTOR'S NOTE: The students will recognize symptoms and find and correct troubles during the energizing procedures.

DEMONSTRATION:

1. Locate and review the function of the following:

   a. Preselector,

   b. Local oscillator,

   c. Local-oscillator power supply,

   d. Signal mixer,

   e. AFC mixer,

   f. IF preamplifier,

   g. IF amplifier,

   h. Sensitivity time control,

i. Switcher-mixer, and

j. Video amplifier channel (to face of PPI).

> INSTRUCTOR'S NOTE: Stress importance and show use of meter M1 (voltages used at barbette) and the CRYSTAL CURRENT meter.

2. At the tracking console, demonstrate the operation of the RECEIVER GAIN and STC control.

3. Disconnect the input cable to the if amplifier, and illustrate the use of receiver noise in troubleshooting.

> INSTRUCTOR'S NOTE: Show the students the effects of using a screw driver to short out the input cable.

4. Follow the video, using the test amplifier, through the switcher-mixer, the video-and-mark mixer, and the PPI video amplifiers.

> INSTRUCTOR'S NOTE: Each student should have an opportunity to monitor the video.

5. Disable one PPI video amplifier and show that it does not affect the other.

6. Locate cable changes necessary to make preselector adjustments. Have students set up synchroscope and monitor video at the test jack at the barbette.

> INSTRUCTOR'S NOTE: Make certain the students understand the importance of the setting of the receiver operating controls.

SUGGESTED TROUBLES:

1. Primary.

There will be no primary troubles for this exercise.

2. <u>Review.</u>

a. Have students perform the computer daily checks.

b. Results should be recorded in the log book.

c. Misadjust the 320v power supply.

# LESSON PLAN

## ACQUISITION RECEIVER
## (Part I)

**OBJECTIVE:**

To present the function and operation of the:

1. Preselector,
2. Local oscillator,
3. Local-oscillator power supply,
4. Signal mixer,
5. IF preamplifier, and
6. Sensitivity time control.

**INTRODUCTION:**

In the preceding lesson, the block diagram of the acquisition receiver system was covered. The block diagram gave a good over-all picture of the function of the receiver. This lesson will deal with the method used for accomplishing that function. The student will learn exactly what happens to the target-return echoes in the first part or the "front end" of the receiver.

**PRESENTATION:**

1. Receiver Block Diagram.

| INSTRUCTOR'S NOTE: The complete receiver (less the AFC and the MTI) will be covered briefly on a block-diagram level. It is essential that the student know the function of the entire system. |
|---|

a. The preselector cavity provides high selectivity.

1) The cavity is tunable over the entire frequency range of the magnetron (3, 100 to 3, 500 mc).

2) The resonant frequency of the cavity is varied by changing the physical size of the cavity.

3) This is done by the receiver-tuner motor which is controlled by the AFC.

4) The output of the preselector is fed to the signal mixer.

b. The local oscillator provides a cw signal that is mixed with the receiver echo to produce the intermediate frequency.

1) The frequency of the local oscillator is tuned to 60 megacycles above the magnetron frequency by the AFC.

2) The size of the resonant cavity and the repeller-plate voltage is altered to change the frequency of the output.

3) The output is sent to the signal mixer.

c. The local-oscillator power supply furnishes the dc voltages necessary for the local-oscillator operation and supplies the keep-alive voltage to the TR tube and filament voltage to the local-oscillator tube, the AFC unit, and the if preamplifier.

d. The signal mixer detects the intermediate frequency and sends it to the if preamplifier.

e. The if preamplifier strengthens the if signal to overcome cable losses and provide a high signal-to-noise ratio.

1) The first two stages are grounded-grid triode amplifiers used to reduce random tube noises to a minimum.

2) The triode amplifiers provide good frequency stability for further amplification.

3) The three final stages are high-gain pentode amplifiers.

4) The signal is coupled between stages by transformers which are heavily loaded to give the desired bandpass.

5) The STC and receiver-gain control potentials are applied to the grid circuits of the final three stages.

f. The if attenuator, which is variable from 20 decibels to 40 decibels in steps of 5 decibels, compensates for tube and circuit aging in the receiver.

g. The if amplifier amplifies the if signal and detects the video.

1) The first six stages are identical voltage amplifiers.

2) Transformer coupling is used throughout.

3) The transformers have loading resistors across the windings to give the necessary bandpass.

4) The V7 is a conventional, high-gain power amplifier.

5) The final stage is a dual diode connected in a manner that will produce both a negative and positive output.

6) The negative, bypass video is applied to the switcher-mixer.

7) The positive, MTI video is sent to the MTI modulator channel.

h. The switcher-mixer provides a means for presenting MTI video during the initial portion of the sweep and bypass video for the remainder of the sweep.

1) Tube V1 is a conventional, one-shot, cathode-coupled multivibrator with a positive, output pulse.

| INSTRUCTOR'S NOTE: Remind the students that V1 is replaced by a phantastron in systems 726 and above. |
|---|

2) The duration of the pulse is determined by setting the MTI RANGE knob.

3) The positive pulse allows V5 to conduct, and MTI video is presented at the output.

4) The output of V1 is inverted by V2 and sent to switch tube V3.

5) The negative output of V2 cuts off V3.

6) At the end of the pulse, V5 cuts off because of the negative bias on the suppressor grid.

7) Tube V3, which has no fixed bias on the suppressor grid, conducts at the end of the pulse, and bypass video is presented for the remainder of the sweep.

8) Clamper V4 establishes the operating level for suppressor grids of V3 and V5.

9) Mixer V6 unites the MTI, bypass video with the IFF information.

i. The video-and-mark channel provides a means of mixing the video with the marks necessary for proper PPI and precision-indicator display.

1) Video amplifier V5 amplifies and inverts the negative video input.

2) The video is mixed with the positive marks at the input to V7.

3) Tube V7 is a conventional cathode follower that matches the impedance of the coaxial line.

j. The PPI video amplifier V4 amplifies and inverts the video and marks and applies the composite signal to the cathode of the PPI tube.

k. The precision-indicator video amplifier V2 is conventionally designed and functions the same as the PPI video amplifier.

2. Preselector Operation.

a. The preselector contains a tunable cavity, a coupling post, and two coupling windows.

| INSTRUCTOR'S NOTE: Use training aid to illustrate the cavity. |
|---|

b. The cavity is tuned by changing its physical size.

1) The cavity is geared to the receiver tuner motor.

2) If the size of the cavity is increased, the resonant frequency is decreased.

3) If the size of the cavity is decreased, the resonant frequency is increased.

c. The coupling windows couple the return echo into the cavity and out of the cavity to the signal mixer.

d. The coupling post increases the attenuation of unwanted signals, particularly the image frequency.

e. A damping ring is incorporated to prevent spurious oscillations.

3. Local-Oscillator Operation.

a. A reflex klystron is used as the local oscillator.

| INSTRUCTOR'S NOTE: This is the first klystron the students are exposed to in the equipment portion of the course. Briefly explain the operation of a klystron. |
|---|

b. The external cavity and the repeller-voltage potentiometer are geared to the tuner motor.

c. Electrons flow from the cathode toward the resonator grids and cause a slight oscillation in the resonant cavity.

1) Most of the electrons pass on to the repeller plate where they are repelled toward the grids.

2) The electrons tend to bunch because of the alternating field around the grids.

3) Oscillations may be sustained by causing the electrons to return to the grids at the proper time.

4) This is done by changing the size of the cavity and the repeller-plate voltage.

4. <u>Local-Oscillator Power Supply and Circuit Operation (fig 6-3).</u>

a. Tube V1 is a full-wave rectifier with the cathode grounded to give a negative output.

b. A negative, 800v, keep-alive voltage for the TR tube is developed across regulator tubes V2 through V6 and resistors R3 through R8.

| INSTRUCTOR'S NOTE: Review the operation of voltage-regulator tubes. |
|---|

c. A -625 volts tapped from the junction of R3 and R4 and -400 volts from pin 2 of V7 are applied, through the spread and level controls, to the repeller pot.

1) Tube V10 maintains a potential difference of 108 volts between the junction of R30A and R28 and the junction of R30B and R29.

2) Spread control R31 and level control R30 provide a means of adjusting the repeller for proper operation throughout the frequency range of the local oscillator.

3) Tube V7 insures a minimum difference of 75 volts between the cathode and plate voltage of the local oscillator.

d. The 6.3-filament voltage is available at the secondary of T2.

5. Signal-Mixer Operation (fig 6-3).

   a. The local-oscillator signal and the received echo are mixed across a mixer loop.

      1) One end of the mixer loop is terminated by crystal diode CR2 which detects the if signal.

      2) The input signals, sum, and harmonic frequencies are eliminated by an rf filter located at the output point of the signal mixer.

   b. The intermediate frequency is conveyed to the if preamplifier (fig 6-7) by coaxial cable.

6. The IF Preamplifier and Its Circuit Operation (fig 6-7).

   a. The if signal is applied to the cathode of V1.

| |
|---|
| INSTRUCTOR'S NOTE: This is the first the students have heard of a grounded-grid amplifier. Its operation and advantages should be covered in detail. |

      1) The proper input impedance is provided by Z1.

      2) Resistor R1 and capacitor C5 provide bias for V1.

      3) The output is coupled to V2 by transformer T1.

      4) Transformer T1 is overcoupled to broaden the bandpass.

   b. Tube V2 amplifies the signal and presents it to V3.

      1) Resistor R4 detunes inductance L5 to broaden the bandpass of V2.

      2) The signal is coupled to V3 through C9.

   c. The last three stages are conventional, high-gain voltage amplifiers.

## 7. The STC and Acquisition Receiver Gain Control Circuit Operation.

a. Multivibrator V1 is triggered by the preknock pulse.

1) Tube V1 is a one-shot, cathode-coupled multivibrator with the A-section normally cutoff.

| INSTRUCTOR'S NOTE: V1 will be covered in detail since this is the first one-shot multivibrator covered in the equipment portion of the course. |
|---|

2) When the preknock is applied, V1A starts conducting, and the resulting drop in plate voltage starts the cutoff action of V1B.

3) The period that V1B is cutoff depends upon the length of time needed for C3 to discharge through R9 to a potential which will allow the grid to rise to a level sufficiently positive to allow V1B to conduct.

4) When the B-section conducts, the A-section cuts off and remains in that state until the next preknock pulse.

5) The output is a positive pulse approximately 35 volts in amplitude.

6) The length of the pulse, which is variable from 10 to 30 microseconds, is determined by the setting of potentiometer R2.

b. The positive output of the multivibrator is applied to cathode follower V2A.

1) A positive waveform, approximately 15 volts in amplitude, is developed across R11.

2) Capacitor C5 charges to this level through CR1 and CR4.

3) At the end of the pulse, C5 discharges through R13 and R14.

4) The setting of R13 determines the length of time it takes for C5 to discharge.

5) The discharge time of C5 may be varied from 30 to 100 microseconds.

c. Tube V3A is a conventional cathode follower with an output of roughly 17 volts.

d. The input to V2B is coupled through C6 and rides on a negative, 8v bias applied through CR2.

1) The output amplitude is controlled by R6, the STC control.

2) The amplitude may be varied from 0 volts to 19 volts.

e. Cathode follower V3B is biased at a high-positive potential with its output approximately the same amplitude as the input.

f. The STC signal is clamped at a voltage determined by the setting of R5, the acquisition receiver gain control.

1) Resistors R4 and R5 constitute the voltage divider for the acquisition receiver gain control voltage.

2) With the STC knob fully counterclockwise, only the manual gain control voltage has effect on the receiver.

<u>SUMMARY:</u>

1. The preselector passes the desired frequency and attenuates all others.

2. The signal mixer mixes the return echo with the local-oscillator output to produce an intermediate frequency.

3. The if preamplifier is used to overcome cable losses and to provide a high signal-to-noise ratio.

4. The local-oscillator output is mixed with the return signal to produce an if signal.

5. The local-oscillator power supply provides voltages for the local oscillator and TR tube, and filament supply for the AFC, the local oscillator, and the if preamplifier.

COMMON TROUBLES:

| Symptoms | Probable Cause |
| --- | --- |
| Weakness or complete loss of acquisition video. | Bad crystal in the signal mixer. |
| | Pickup probe to the local oscillator pulled out by equipment vibration. |

# PRACTICAL EXERCISE

## ACQUISITION RECEIVER
## (Part I)

AAFCS M33 SETUP:

1. The equipment will be deenergized.

2. The students will find and correct troubles during the energizing procedure.

EQUIPMENT NECESSARY: Multimeter, test amplifier, and synchroscope.

PRELIMINARY TROUBLES:

1. Open sync pulse distribution between the rf and modulator units.

2. Replace the magnetron with a bad one if available.

DEMONSTRATION:

1. Locate and review the function of the following:

   a. TR tube and keep-alive voltage,

   b. Preselector,

   c. Signal mixer,

   d. AFC mixer,

   e. Meter panel,

   | INSTRUCTOR'S NOTE: Explain the use of the meter panel as a troubleshooting aid. |
   |---|

   f. Local oscillator,

g. Receiver tuner motor,

h. Repeller-plate pot,

i. Local-oscillator power supply,

j. IF preamplifier, and

k. IF amplifier and attenuator.

2. Demonstrate the preselector adjustments.

| INSTRUCTOR'S NOTE: Have each student perform the adjustment. |
|---|

SUGGESTED TROUBLES:

1. Primary.

   a. Faulty V6 in the switcher-mixer.

   b. Faulty V7 in the video-and-mark mixer.

   c. Replace signal mixer crystal with a bad one.

   d. Replace 6BL6 with a bad tube.

   e. Replace V2 in the if amplifier.

   f. Replace V3 in the if preamplifier.

2. Review.

   a. Have students perform and record the daily computer checks.

   b. Some time should be spent on chassis location.

# LESSON PLAN

## ACQUISITION RECEIVER
## (Part II)

OBJECTIVE:

To present the detailed function and operation of the:

1. IF amplifier,

2. Switcher-mixer, and

3. Video amplifier channel.

INTRODUCTION:

The preceding lesson showed the detailed operation of the circuitry which converts the return echo into an if signal and transfers that signal to the van. This lesson will pick up the if signal from the preamplifier and carry it all the way to the face of the cathode-ray tubes.

PRESENTATION:

1. Block-Diagram Review of the Receiver.

| INSTRUCTOR'S NOTE: Continuous review of the function of the units contained in the receiver will insure a sound over-all knowledge on the part of the student. It will not be necessary to spend too much time on this block discussion. |
|---|

a. The mixer channel passes the desired signal.

1) All other frequencies are attenuated.

2) The return echo is converted into a frequency which is in a more usable range.

b. The if amplifier channel amplifies and detects the signal containing target information.

c. The switcher-mixer switches the MTI to bypass video and combines it with the IFF information.

d. The video-and-mark channel adds to the video the marks which complete the PPI and presentation display.

e. Each PPI and precision indicator contains a separate video amplifier.

2. The IF Attenuator (fig 6-7).

INSTRUCTOR'S NOTE: This is the first attenuation network of this type that the students have encountered. Each student should have a good knowledge of this type of network by the end of the class.

a. A fixed attenuation of 20 decibels is presented by R32, R33, and R34.

b. Switch S1/A50 provides an additional 0- to 20-decibel deviation in attenuation in steps of 5 decibels.

3. The IF Amplifier and Its Circuit Operation (fig 6-8).

a. The first six stages are identical voltage amplifiers.

1) Transformer T1 couples the signal to the grid of V1.

2) Resistor R1 loads T1 to broaden the bandpass.

INSTRUCTOR'S NOTE: Explain the need for a broad bandpass.

3) Resistor R2 and capacitor C3 provide bias for V1.

4) Resistor R3 loads the primary of T2 for a broad bandpass.

5) Operation of tubes V2 through V6 is identical to the operation of V1.

b. Power amplifier V7 amplifies the signal and presents it to detector V8.

1) Bias for V7 is provided by R49 and C39.

2) The broad bandpass is maintained by R48 and R50.

c. Detector V8 provides two video outputs of opposite polarity.

1) Positive, MTI video is taken off the A-section, and negative, bypass video is detected by the B-section.

2) The LC networks in the output circuits of both sections filter the intermediate (60 mc) frequency.

4. <u>The Switcher-Mixer and Its Circuit Operation (fig 6-9).</u>

a. The preknock pulse is coupled through C1 to V1, a one-shot, cathode-coupled multivibrator.

| INSTRUCTOR'S NOTE: Remind the students that this multivibrator is replaced by a phantastron circuit in systems 726 and above. |
|---|

1) Normally, the A-section is cutoff, and the B-section is conducting heavily.

2) When the preknock pulse is applied, the A-section conducts, and because of the resulting circuit action, the B-section cuts off.

3) The sharp rise in plate voltage of the B-section is coupled through C5 to the control grid of V2 and the suppressor grid of V5.

4) The duration of the output waveform is controlled by the setting of R2/B7, the MTI range potentiometer.

5) CR3 allows C11 to charge quickly and maintain the dc level constant at the grid of V1A.

b. The positive output of V1 is inverted by V2 and applied to V3.

1) Resistor R12 determines the amplitude of the pulse applied to V3.

2) Resistor R12 is adjusted to cut off V3 and allow it to start conduction the instant V5 is cut off.

3) If V3 and V5 were cut off at the same instant, a ring would appear on the PPI.

c. During the absence of a gate pulse, V5 is held cutoff by the negative potential from voltage divider R23 and R24.

1) The positive gate pulse overcomes the bias on the suppressor grid, and V5 conducts.

2) The MTI video applied to the control grid will be present at the output for the duration of the pulse.

3) Tube V4A clamps the suppressor grid at ground level.

d. Bypass video is coupled to the grid of V3 through C6.

1) The amplitude of the video is controlled by R13.

2) The negative pulse from V2 applied to the suppressor grid causes plate current to be cut off.

3) At the end of the pulse, V3 conducts and bypass video replaces MTI video in the common plate circuit of V3 and V5.

4) Resistor R16 is adjusted so that the intensity of the bypass and MTI portions of the sweep are the same.

5) The suppressor grid of V3 is clamped at ground by V4B.

6) If the MTI switch is in the OFF position, there is no multivibrator action, and bypass video is presented for the entire length of the sweep.

e. The video is coupled through C8 to the control grid of V6A.

1) Bias for V6A and V6B is provided by voltage divider R27 and R29.

2) The IFF information is applied to the grid of V6B.

3) The bypass and MTI video are mixed with IFF information in the common plate circuit for both sections.

| |
|---|
| INSTRUCTOR'S NOTE: Point out that the plate voltage for V6 comes from the video-and-mark mixer. The coaxial cable is therefore hot. |

f. The output is conveyed to the video-and-mark mixer by coaxial cable.

5. Video-and-Mark Channel Circuit Operation (fig 6-10).

a. The negative video is coupled through C15 to the grid of V5.

1) Crystal CR7 clamps the signal at a negative level determined by voltage divider R44 and R46.

2) The positive signal is coupled through R53, C20, and R57 to the grid of V7.

3) The video and marks are mixed at the junction of R52 and R53.

b. Tube V7 is dual-triode connected with both sections in parallel to operate as a cathode follower.

1) The voltage divider of R56 and R58 provides a -5.8v fixed bias.

2) Crystal CR9 clamps the signal at the bias level.

3) The output is fed through coaxial cable to the precision indicators and PPI.

c. MTI meter M1 when in the BAL position is connected to read the average dc voltage on the ACQ video cable.

1) A bias, controlled by MTR set control R5/A29, is provided (through the meter) to balance out most of the dc voltage on the video cable.

2) When the FINE BAL switch is operated, some of the resistance is shorted and makes the circuit more sensitive.

3) The meter can be used as an indication of baseline step.

4) Optimum balance is reached when the meter set is adjusted for minimum reading on the MTI meter with the MON BAL switch in the BAL position.

6. The PPI Video Amplifier and Its Circuit Operation (fig 7-11).

INSTRUCTOR'S NOTE: Tell the students that there are two PPI video amplifiers, one for each PPI, which are identical and interchangeable.

a. The video is applied to the grid of V4 through contacts 1 and 9 of K1, R5, and C8.

1) Fixed bias is developed by voltage divider R18 and R20.

2) Crystal CR1 clamps the signal at the level of the bias voltage.

3) Resistor R5 is varied by the GAIN control knob on the face of the PPI.

b. The output, negative video and marks, is applied directly to the cathode of the PPI.

7. Precision-Indicator Video Amplifier and Its Circuit Operation (fig 10-3).

> INSTRUCTOR'S NOTE: Tell the students that there are two precision indicators, each with its own video amplifier, which are identical and interchangeable. The individual video amplifiers are also interchangeable.

a. The video is applied to video amplifier V2 through R9 and C5.

1) Fixed bias is developed by voltage divider R8 and R10.

2) Crystal CR1 clamps the signal at the bias voltage level.

3) The setting of R9 is varied by the GAIN control knob on the front of the precision indicator.

b. The output is applied to the cathode of the PI tube.

SUMMARY:

1. The if attenuator compensates for aging of components.

2. Two outputs are obtained from the if amplifier: bypass video and MTI video.

3. The switcher-mixer provides a means of switching from MTI to bypass video and of mixing the video with IFF information.

4. The video is mixed with the marks in the video-and-mark channel.

5. Negative video and marks are applied to the cathodes of the PPI and PI tubes by their respective video amplifiers.

> INSTRUCTOR'S NOTE: Inform the students that the ACQ receiver control units for systems 726 and above are not interchangeable with the control units for preceding systems. Should an interchange be attempted, the MTI range would increase when the operator tried to decrease the range, etc.

COMMON TROUBLES:

| Symptoms | Probable Cause |
|---|---|
| No video or marks on PPI or precision indicators. | V7, video-and-mark mixer, bad. |

Note: Comparatively few troubles occur in this portion of the receiver channel.

# PRACTICAL EXERCISE

## ACQUISITION RECEIVER
## (Part II)

AAFCS M33 SETUP:

The equipment will be completely deenergized.

EQUIPMENT NECESSARY:

1. Multimeter,
2. Test amplifier, and
3. Frequency power meter.

PRELIMINARY TROUBLES:

1. Replace the local-oscillator tube with a bad one.
2. Turn GAIN and INTENSITY controls to minimum.

> INSTRUCTOR'S NOTE: The students should find and correct the trouble during the energizing procedure.

DEMONSTRATION:

1. Using the test amplifier, follow the video from the input of the switcher-mixer to the face of the PPI.

> INSTRUCTOR'S NOTE: Each student should monitor the video along this channel.

2. During the demonstration of the video stages, review the function of each unit.

3. Demonstrate the switcher-mixer adjustments.

| INSTRUCTOR'S NOTE: Each student will perform the adjustments. |
|---|

4. Demonstrate the sensitivity time control adjustment.

| INSTRUCTOR'S NOTE: Each student will perform the adjustment. |
|---|

SUGGESTED TROUBLES:

1. Primary. Place the following troubles in the equipment.

   a. Defective V1 in STC.

   b. Defective V3 in the switcher-mixer.

   c. Filament to cathode short V6 (pin 3 to 8) in the switcher-mixer.

   d. Open terminal No. 97/A (B+ to if preamplifier).

   e. Bad tube in PPI video amplifier.

2. Review.

   a. Have students perform computer daily checks and fill in log book.

   b. Measure the ACQ frequency and power.

   c. The remaining time should be spent in the location of various units including those not yet covered.

# LESSON PLAN

## ACQUISITION AUTOMATIC FREQUENCY CONTROL (Part I)

OBJECTIVE:

To present the function and the operation of the:

1. AFC mixer,
2. IF amplifiers,
3. Limiter,
4. Discriminator,
5. Video amplifier, and
6. Pulse stretcher.

INTRODUCTION:

Up to this point in the course, a pulse of rf energy has been developed and transmitted, and the target reflections have been received and displayed on the cathode-ray indicators. To insure receiver operation at the transmitter frequency, AFC is employed. If the transmitter changes frequency, the AFC detects the change and tunes the receiver automatically to the new frequency.

PRESENTATION:

1. The AFC Channel Block Diagram (fig 6-1).

   a. The AFC mixer combines the local-oscillator output and a sample of the transmitted pulse to produce an intermediate frequency.

| INSTRUCTOR'S NOTE: Point out the similarity between the AFC and the signal mixers. Explain the effects of inserting one of the pickup probes too far into the local-oscillator cavity. |
|---|

1) The mixer filters the radio-frequency energy and passes the intermediate frequency to the intermediate amplifier.

2) The intermediate frequency is detected by crystal diode CR1.

b. The if amplifiers V1, V2, and V3 are conventional transformer-coupled if stages.

1) The bandpass of the if amplifiers is 10 megacycles.

2) The amplifiers are given a broad bandpass by loading resistors across the transformer windings.

c. Limiter V4 amplifies weak signals and clips strong signals so that the discriminator receives a signal that is constant in amplitude.

1) The plate is held at a low potential so that strong signals saturate the tube.

2) Grid-leak bias as well as cathode bias is used.

3) The amount of grid current is shown on meter M2/F6 and indicates the operation of the first four stages.

d. The discriminator senses any change in frequency and converts the shift into a series of pulses.

1) The amplitude of the pulses is proportional to the amount of frequency deviation.

2) The polarity of the pulses is determined by the direction of frequency shift.

3) Positive pulses are developed if the intermediate frequency drops below 60 megacycles.

4) If the input frequency goes above 60 megacycles, the output pulses are negative.

e. Video amplifier V6A, which is conventional in design, amplifies the discriminator output and sends it to the center tap of the secondary of transformer T6.

f. The pulse stretcher converts the positive or negative pulses to a dc voltage for use in the balanced modulator.

1) A positive pulse is obtained from the pulse transformer to gate the pulse stretcher for the desired period only.

2) A crystal in the grid circuit of cathode follower V6B clips the ragged top of the gate pulse.

3) The pulse stretcher may be considered as a capacitor that has a short charge time and a very long discharge time.

4) The dc level to which the capacitor charges during the input pulse is maintained relatively constant during the period between pulses.

5) As a result, the output is an almost constant dc potential.

g. The balanced modulator provides a 400-cycle output whose phase and amplitude correspond to the polarity and magnitude of the dc input.

1) In the absence of a dc control voltage, there is no output.

2) When the control voltage is present, an unbalance is created, and a 400-cycle voltage is developed.

3) The ac output from the modulator determines the amount and direction of rotation of the receiver-tuner motor.

h. Inverter amplifier V10 converts the push-pull output of the balanced modulator to a single-ended signal and feeds it to the LPSA.

i. Two low-power servo amplifier boosts the signal strength to a level sufficient to operate the tuner motor.

1) The first two stages are voltage amplifiers.

2) The signal from the second stage is converted to a push-pull voltage by a paraphase amplifier.

3) The final output stage is a push-pull power amplifier feeding a transformer that converts the signal to a single-ended voltage.

j. The receiver-tuner motor is a two-phase ac motor.

1) When the output from the LPSA is applied, the motor turns in a direction determined by the phase of the signal.

2) When the intermediate frequency returns to 60 megacycles, the LPSA no longer has an output, and the motor stops.

3) The tuner motor drives the repeller-plate potentiometer, the local-oscillator runing piston, the preselector tuning piston, and switch S13/F2.

k. When the input to the if amplifier varies more than five megacycles above or below the intermediate frequency, the signal cannot pass through the if amplifier. At this point, the auto-search circuits take control.

1) The action of the balanced modulator and the circuits which follow is the same as in normal operation.

2) A relay deenergizes and applies a dc voltage to the balanced modulator through the pulse stretcher.

3) A negative, 15 volts are applied to cause the tuner to search up through its frequency range at a very fast rate.

4) The relay while deenergized prevents the AFC from locking on the lower sideband while searching up.

5) At the upper-frequency limit, S13 is operated energizing a relay.

6) The relay switches the autosearch voltage to a positive 5 volts.

7) The tuner searches down through its frequency range and locks on the intermediate frequency.

2. <u>The AFC Mixer Operation (fig 6-3).</u>

a. A sample of the transmitter pulse is taken from the waveguide between the magnetron and the ATR tubes through a coupling window.

b. Energy is extracted from the local oscillator by a pickup probe in the resonant cavity.

c. A directional coupler feeds energy from the local oscillator into the mixer line.

1) A powdered iron core at the termination of the coupler attenuates the local-oscillator energy.

2) Matching is obtained by using dielectric rings.

d. The crystal mounted in one wall of the mixer at the end of the mixing line detects the if signal.

e. The input frequencies, sum, and harmonic frequencies are filtered out by the rf filter at the if output line.

3. The IF Amplifier Operation (fig 6-4).

   a. The input from the AFC mixer is applied to V1 through transformer T1.

      1) The AFC crystal current flows from ground through meter M2/F6 or R25 and R15, the primary of T1, and back through the crystal to ground.

      2) Resistors R28 and R5 provide a broad bandpass.

      3) Resistor R1 and capacitor C6 provide cathode bias for V1.

      4) The signal is coupled to V2 through T2.

   b. The operation of V2 and V3 is the same as that of V1.

4. Limiter V4 and Its Circuit Operation.

   a. Tube V4 is operated at a low-plate voltage so that the tube is easily saturated.

   b. Grid-leak bias is developed by R22 and C4.

      1) Grid current flows from the grid through the secondary of T4, R22, R17, and R26.

      2) The limiter current is read on the meter M2/F6 and indicates the performance of the first four stages.

   c. Weak signals are amplified, while strong signals overdrive V4 and are limited.

→ 5. Discriminator V5 and Its Circuit Operation.

   a. The secondary of T5 is a series resonant circuit tuned to 60 megacycles.

      1) When the input signal is 60 megacycles, the circuit reactances are equal, and V5A and V5B conduct equally.

2) Therefore, the charges on C18 and C19 are equal, and there is no output.

3) If the input is not 60 megacycles, the inductive and capacitive reactances are unequal, and the resultant voltages at opposite ends of the circuit are different in amplitude and phase.

4) Tubes V5A and V5B will not have equal conduction.

5) Capacitors C18 and C19 will not charge to the same amount, and a series of pulses will result.

6) The magnitude of the pulses is dependent upon the amount of frequency deviation.

7) The polarity of the pulses is determined by the direction of frequency deviation.

b. The output is taken from the junction of R14 and R67 and applied to V6A.

6. <u>Video Amplifier V6A.</u>

a. Tube V6A is a straightforward video amplifier using degeneration to retain the pulse shape.

b. The output is coupled through C20 to the center tap of T6 in the pulse stretcher.

7. <u>Cathode Follower V6B (fig 6-5).</u>

a. Gate pulses from the pulse-transformer circuit are applied through R24 to the control grid.

1) The ragged tops of the pulses are clipped by CR1.

2) The bottom of CR1 is held at +26 volts by the voltage divider R19, R60, and R62.

3) If the pulse goes above 26 volts, CR1 conducts, and the resulting current through R24 holds the amplitude at 26 volts.

b. The output, a positive pulse on the order of 20 volts, is coupled through C36 to the primary of T6.

8. <u>Pulse Stretcher V7A and V7B and Its Circuit Operation.</u>

a. The gate pulses at the primary of T6 appear as negative pulses at the top of the secondary and as positive pulses at the bottom of the secondary.

1) The pulses cause V7A and V7B to conduct an equal amount.

2) The resistor-capacitor combinations in the plate circuits develop a bias that holds the tubes cutoff between pulses.

b. The input from the discriminator adds to the gate pulse at one end of the secondary and subtracts from the gate pulse at the other end.

1) If the input from the discriminator is positive, the pulse applied to V7A will be of larger amplitude than the pulse applied to V7B.

2) Conduction of V7A is larger than V7B, and capacitor C23 charges positive.

3) Capacitor C23 holds this charge because of the long discharge time constant.

4) The dc level will change with an amplitude change of the input from the discriminator.

5) Operation for a negative input is the opposite.

c. The dc output is applied to the balanced modulator.

SUMMARY:

1. The purpose of the AFC channel is to provide continuous frequency correction for the receiver.

2. The AFC mixer provides an if signal.

3. The if amplifiers have a bandpass of 10 megacycles.

4. The discriminator detects any frequency shift and provides a series of positive or negative pulses at its output.

5. The pulse stretcher converts the pulses to a dc voltage.

COMMON TROUBLES:

| Symptoms | Probable Cause |
| --- | --- |
| AFC will not lock on. | Bad crystal in the AFC mixer. |

INSTRUCTOR'S NOTE: Explain the method of localizing the trouble. If there is AFC mixer current but no limiter current, the trouble is probably in the first four stages of the AFC unit. If there is no AFC mixer current, and the meter indicates signal-mixer crystal current, the trouble is in the pickup probe or the crystal. If there is no AFC mixer current and no signal-mixer crystal current, check the local oscillator. If it is possible to get AFC crystal current and limiter current, the trouble is beyond the limiter stage.

# PRACTICAL EXERCISE

## ACQUISITION AFC
## (Part I)

AAFCS M33 SETUP:

The equipment will be completely deenergized.

EQUIPMENT NECESSARY: Multimeter, test amplifier, and synchroscope.

PRELIMINARY TROUBLES:

1. Defective V8 in the if amplifier.
2. Local-oscillator cavity-coupling probes withdrawn.

> INSTRUCTOR'S NOTE: The students should find and correct the trouble during the energizing procedure.

DEMONSTRATION:

1. Locate and review the following:

   a. AFC mixer,

   b. Crystal-current meter M2,

   c. AFC if amplifiers,

   d. Discriminator,

   e. Video amplifier,

   f. Pulse stretcher,

   g. AFC gate cathode follower,

h. Autosearch relays,

i. Balanced modulator,

j. Low-power servo amplifier, and

k. Receiver tuner motor.

2. Demonstrate the use of the synchroscope in monitoring the output of the discriminator.

3. Show how the limiter current may be obtained through manual tuning.

4. Remove any of the first four stages and note the effect.

| INSTRUCTOR'S NOTE: Cover troubleshooting procedure for these stages. |
|---|

5. Demonstrate the use of the HUNT indicator lamp.

SUGGESTED TROUBLES:

1. Primary.

   a. Insert probe to signal mixer all the way in and extract the AFC probe from the local-oscillator cavity.

   b. Replace V2 with a faulty tube (AFC unit).

   c. Remove AFC crystal.

   d. Open terminal No. 98/A (+250 volts to ACQ antenna).

2. Review.

   a. Replace one of the if amplifier tubes with a bad tube.

   b. Have students perform the daily checks on the computer.

   c. Misadjust the 320v supply in the computer.

   d. Place a bad tube in one of the computer dc amplifiers.

# LESSON PLAN

## ACQUISITION AFC
## (Part II)

**OBJECTIVE:**

To understand the function and operation of the:

1. Balanced modulator,
2. Inverter amplifier,
3. Low-power servo amplifier,
4. Tuner motor, and
5. Autosearch circuit.

**INTRODUCTION:**

In the preceding lesson, any frequency deviation by the magnetron was detected by the discriminator. The result was a series of positive or negative pulses that were converted into a steady dc voltage by the pulse stretcher. This lesson will show how the dc voltage is converted into a 400-cycle control voltage that causes the tuner motor to tune the receiver to the magnetron frequency.

**PRESENTATION:**

1. Acquisition AFC Block Diagram.

   a. The AFC mixer beats the local-oscillator output with a sample of the transmitted frequency.

   b. The if amplifiers amplify the difference frequency if it is within the 10-megacycle bandpass.

c. The limiter amplifies the weak signals and limits the strong peaks so that its output is of constant amplitude.

d. The discriminator detects any change in the if frequency and produces a series of positive or negative pulses depending on the direction of frequency shift.

1) The amplitude of the pulses corresponds to the amount of change.

2) The output is fed to the pulse stretcher through a video amplifier.

e. The pulse stretcher converts the pulses into a relatively constant dc voltage.

f. The balanced modulator converts the dc voltage into a 400-cycle error voltage.

1) The amplitude of the 400-cycle signal corresponds to the magnitude of the dc voltage.

2) The phase of the error signal corresponds to the polarity of the dc voltage.

g. The low-power servo amplifier builds the signal amplitude to a level sufficient to drive the tuner motor.

h. The tuner motor tunes the preselector, local-oscillator cavity, and the repeller-plate potentiometer so that the receiver is tuned to the correct frequency.

i. Should the difference frequency go beyond the if bandpass, the autosearch circuits take control and drive the tuner throughout the entire frequency range, finally locking on the upper sideband.

2. Balanced Modulator and Its Circuit Operation (fig 6-5).

a. Four tubes comprise a balanced bridge circuit.

1) The dc control voltage is applied to the grids of V8A and V9B.

2) A fixed dc voltage is applied to the grids of V8B and V9A.

3) The cathodes receive a 400-cycle input.

b. In the absence of a dc control-voltage input, there is no output.

1) Resistor R43 is adjusted so that the ac output of V9A and V8B is the same as the dc output of V9B and V8A.

2) The signals at the cathodes of V8A and V9A are 180° out of phase.

3) The plates of V8A and V9A are tied together, and, since the signals are equal in amplitude and 180° out of phase, they cancel.

4) Tubes V8B and V9B operate the same as V8A and V9A.

c. There will be a 400-cycle output when the dc control voltage is applied.

1) If the control voltage is positive, the gain of V8A and V9B increases.

a) Since the signal at the plate of V8A is of greater amplitude than the signal at the plate of V9A, the two signals will not completely cancel.

b) The result is a voltage coupled through C30 to V10A.

c) The output of V9B will be greater than the output of V8B.

d) There will be a 180° phase difference between the outputs of the A- and B-sections.

2) If the control voltage is negative, the gain of V8A and V9B decreases, and circuit operation is the reverse of that for a positive input.

3. Phase Inverter V10 and Its Circuit Operation (fig 6-6).

   a. The push-pull output of the balanced modulator is converted to a single-ended signal by V10.

      1) The output of cathode follower V10A is developed across R63, the common cathode resistor for V10A and V10B.

      2) The input to the grid of V10B is 180° out of phase with the cathode signal, and the two signals aid.

   b. The output, a composite of the two inputs, is coupled through C32 to the LPSA.

→ 4. Low-Power Servo Amplifier and Its Circuit Operation (fig 16-13).

   a. Tubes V1A and V1B are voltage amplifiers.

      1) A degenerative feedback is taken from cathode resistor R8 of V1A and applied to the grid of V1B.

      2) The purpose of the feedback is to overcome any tendency for the circuit to oscillate.

   b. Tubes V2A and V2B convert the signal to a push-pull voltage.

      1) The output of V1A is applied to the grid of V2A.

      2) Tube V2A functions as a phase splitter with one output taken from its plate circuit and the other developed across R10, the common cathode resistor for V2A and V2B.

      3) Tube V2B functions as a grounded-grid amplifier, and no phase inversion takes place.

   c. Power amplifiers V3 and V4 develop a signal strong enough to drive the tuner motor.

      1) Transformer T1 converts the push-pull signal to a single-ended output.

2) The signal is applied directly to terminal No. 1 of the tuner motor.

5. Tuner Motor V3/F2 (fig 6-6).

a. When acquisition power is turned on, 120 volts phase C are applied to winding 3-4.

1) Ground is applied when K4/F7 is energized.

2) The motor turns in a direction determined by the phase of the input from the LPSA.

b. The motor drives in a direction that tunes the local oscillator to 60 megacycles above the magnetron frequency.

c. The preselector is tuned to the transmitter frequency.

6. Autosearch Circuits and Circuit Operation (figs 6-4 and 6-5).

a. When limiter V4 is drawing grid current, V11B is held close to cutoff.

1) The bias on V11A causes it to conduct heavily and energize K1.

2) Ground is applied to the center tap of T6, and the circuit operates normally.

b. When the if input strays beyond the bandpass of the if amplifier, V11B conducts heavily.

1) The plate voltage of V11B drops because of its heavy conduction.

2) As a result, the voltage at the junction of R64 and R65 swings in a negative direction and cuts off V11A.

3) Relay K1 deenergizes, and the autosearch voltage is applied to the center tap of T6.

4) At the lower limit, switch S13/F2 breaks contact, and K3/F7 deenergizes.

5) A negative, 15 volts is applied to T6 through contacts 1 and 3 of K3 which causes the tuner to sweep up through its range very rapidly.

6) Pins 4 and 6 of relay K3/F7 ground the grid of V11B and prevent the AFC from locking on during the upsweep.

7) At the upper limit, S13/F2 makes contact, energizing K3, and a positive 5 volts is applied to T6 through contacts 2 and 3 of K3/F7.

8) The tuner sweeps down slowly and locks on the 60-megacycles intermediate frequency.

c. Should the receiver lock on the lower sideband, the AFC RELEASE switch may be operated, and the receiver will sweep down in frequency.

1) When the AFC RELEASE switch is operated, relay K2/F7 energizes and +15 volts are applied to transformer T6.

2) When the receiver reaches its lower limit, circuit operation is the same as in 6.b. above.

7. The AFC HUNT indicators flicker continuously when the AFC is locked on the upper sideband (fig 6-6).

a. When the AFC is locked-on the lower sideband, the flicker is slower.

b. When the AFC is not locked-on, there is no glow from the indicators.

<u>SUMMARY:</u>

1. The balanced modulator converts the dc into a 400-cycle voltage.

2. The LPSA amplifies the 400-cycle signal to a level that is sufficient to drive the tuner motor.

3. The tuner motor drives the tuning plungers of the local-oscillator and preselector cavities, the repeller plate potentiometer, and LIMIT switch S13.

4. The autosearch circuits prevent the AFC from locking on during the upsweep.

5. The autosearch circuits take control whenever the if signal from the AFC mixer is outside the 10-megacycle bandpass.

COMMON TROUBLES:

| Symptoms | Probable Cause |
|---|---|
| 1. AFC searches to one limit and stops. | AFC unit out of adjustment (R66). |
| 2. AFC continually searches and never locks on the correct frequency. | Bad signal-mixer crystal. |
| 3. AFC not searching. | Contacts 7 and 8 of K4/F7 stuck in the open position.<br>ACQ magnetron current not sufficient to energize K4/F7. |

# PRACTICAL EXERCISE

## ACQUISITION AFC
## (Part II)

**AAFCS M33 SETUP:**

The equipment will be completely deenergized.

**EQUIPMENT NECESSARY:**

1. Multimeter,
2. Test amplifier, and
3. Null-voltage test set.

**PRELIMINARY TROUBLES:**

1. Replace V2 in the pulse synchronizer with a defective tube.
2. Turn all operating controls to minimum.

**DEMONSTRATION:**

1. Locate and review the following:
    a. Pulse synchronizer,
    b. Trigger generator,
    c. Modulator,
    d. Magnetron,
    e. Duplexer,
    f. Mixer channel,

g. RF sample to AFC mixer,

h. Local oscillator,

i. AFC chassis,

j. AFC LPSA,

k. Tuning motor B3/F2,

l. Linkage tuning motor, local oscillator, repeller-plate pot, and preselector, and

m. AFC release buttons.

> INSTRUCTOR'S NOTE: As each of the above is covered, trace the signals through the block diagram.

2. Point out and demonstrate the following adjustments:

a. Spread and level,

b. RELAY AMP adjustment, and

c. Modulator balance.

> INSTRUCTOR'S NOTE: After the demonstration, have students make the above adjustments.

SUGGESTED TROUBLES:

1. Primary.

a. Misadjust RELAY AMP adjustment.

b. Replace V6 in the AFC chassis with a defective tube.

c. Remove terminal No. 127 RC (fig 6-4).

d. Replace V11 in the AFC chassis with a defective tube.

e. Remove terminal No. 237 TC (fig 6-6).

f. Remove AFC HUNT indicator lamp.

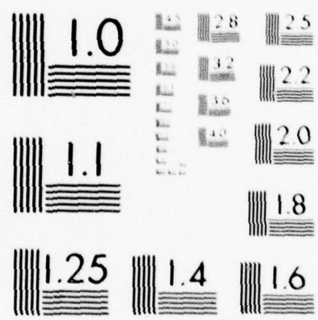
2. Review.

a. Have students monitor computer, dc-amplifier inputs using the null-voltage test set.

b. Review location and function of receiver components with the students who are not engaged in troubleshooting.

AD-A071 775 HUMAN RESOURCES RESEARCH ORGANIZATION ALEXANDRIA VA F/G 5/2
AAFCS M33 TECHNICIAN TRAINING PROGRAM. VOLUME III. ACQUISITION --ETC(U)
JUN 58 DA-49-106-QM-1
UNCLASSIFIED NL

3 OF 4
AD
A071775




MICROCOPY RESOLUTION TEST CHART
NATIONAL BUREAU OF STANDARDS-1963-A

# LESSON PLAN

## MOVING-TARGET INDICATOR SYSTEM
## (Part I)

**OBJECTIVE:**

To present the function and operation of the:

1. Moving-target indicator (complete block diagram),
2. Modulator channel,
3. Delay channel, and
4. Nondelay channel.

**INTRODUCTION:**

In the study of the main portion of the receiver, MTI video was mentioned several times. In this lesson, the student will learn what MTI is, how it is produced, and for what it is used. MTI video is used to its best advantage in mountainous terrain or in congested areas where there are many tall buildings that cause a large amount of ground clutter to appear on the PPI and precision indicators.

**PRESENTATION:**

1. MTI System Complete Block Diagram (fig 6-2).

   a. The MTI modulator generates a 15-mc carrier and modulates it with the preknock pulse and MTI video.

      1) Tube V2 is a Hartley oscillator used to generate the 15-mc carrier.

      2) Tube V1 inverts the preknock pulse and feeds it to modulator V3.

3) It is essential that the preknock and video be opposite in polarity so that they can be separated in later stages.

4) The preknock and video are applied to the suppressor grid of V3; the carrier is fed to the control grid.

5) The output of V3 is the 15-mc carrier modulated by the preknock pulse and the video.

6) The carrier is necessary to convey the MTI video through the quartz-delay line.

7) The rf amplifier V4 reproduces the signal from V3 with fidelity and matches the impedance of the coaxial line.

8) Amplifier V1/A16 amplifies the modulator carrier to a level great enough to excite the input crystal of the quartz-delay cell.

9) The output of V1/A16 is fed to the delay and nondelay channels.

b. The MTI delay channel retards the modulated input for 1, 000 microseconds.

1) Quartz-delay cell Z1 provides the necessary delay.

2) The signal undergoes approximately 65 decibels of attenuation in Z1.

3) Tube V3/A16 is an rf amplifier designed for maximum gain at 15 megacycles per second.

4) Cathode follower V2/A16 acts as a buffer and impedance-matching device between the delay-cell amplifier and the delay amplifier.

5) The 0-to-20 db attenuator, which can be changed in steps of five db, provides a means of equalizing the output amplitudes of the delay and nondelay amplifiers.

6) Stages V1 to V4/A31 are voltage amplifiers whose gain is controlled by an AGC voltage.

7) Power amplifier V5 amplifies the signal and applies it to CR1 and CR2.

8) CR1 and CR2 detect the delay video and the preknock pulse which ride on a negative, four-volt level.

9) The output from CR1 and CR2 is applied to delay line Z1/A29, delay AGC amplifier V2, and the autosync channel.

10) Should the output level change, AGC amplifier V2/A29 would alter the AGC voltage to the grid of V1/A31 and bring the output level back to a negative, 4 volts.

11) Delay line Z1/A29 provides a means for making the output-time relationship of the delay and nondelay channels equal.

12) The output of Z1 is applied to the lower end of R26 (fig 6-2).

c. The MTI nondelay channel introduces attenuation and amplification to the nondelay video by an amount equal to that which the delay video receives.

1) The first four stages are voltage amplifiers that perform the same function as the first four stages in the delay amplifier.

2) The power amplifier is conventional in design. Its output is fed to CR1 and CR2/A30.

3) Crystals CR1 and CR2 detect the signal and feed it to the upper end of R25 in the mixing network (fig 6-2).

4) The output level is a positive, 4 volts.

5) Should the level at the bottom of R26 or the top of R25 change, cancellation would no longer take place, and the resultant signal would be fed to the nondelay AGC amplifier.

6) The output of V8/A29 would then cause a gain deviation in V1 which would bring the output level of the nondelay amplifier to a potential equal to that of the delay channel.

7) The gain of the two channels would then be equal.

8) The nondelay output is applied to the MTI video channel.

d. The MTI video channel is arranged so that the positive and negative video is amplified and appears as a composite, negative signal at the output.

1) Since echoes from fixed targets always return with the same amplitude and time relationship, they are canceled.

2) Moving-target return echoes, resulting from amplitude and time variations, give both positive and negative video.

3) Tube V6/A29 is a conventional video amplifier which amplifies both the positive and negative video.

4) Crystal CR1/A29 passes the negative video and rejects the positive.

5) The input signal to V7 is attenuated so that the output amplitude of CR1 and CR2 will be equal.

6) Tube V7 inverts the output of V6.

7) Crystal CR2 passes the negative portion of the V7 output.

8) The negative MTI video is presented to the switcher-mixer channel.

e. The autosync channel insures transmitter triggering at precise intervals.

1) Amplifier V3 accepts the output signal from the delay amplifier.

2) The bias on V3 is such that only the positive preknock is passed; the negative video is blocked.

3) Autosync amplifier V4 amplifies the signal and presents it to V5.

4) Cathode follower V5 matches the impedance of the coaxial line used to convey the autosync pulse to V1/A25.

5) When the AUTO-INT switch is in the AUTO position, amplifier V1/A25 inverts the pulse and applies it to V2/A25.

f. The test-pulse channel provides a positive pulse which is used for MTI adjustment.

1) Test-pulse driver V3A inverts the sync pulse and applies it to the plate of V3B as a trigger pulse.

2) Tube V3B is a blocking oscillator with a positive output approximately 6 volts in amplitude and 7 to 9 microseconds in duration.

3) The output is applied to modulator V3/A26 when the TEST PULSE switch is in the ON position.

2. <u>The MTI Modulator Channel Circuit Operation (fig 6-11).</u>

a. The preknock pulse is applied to amplifier V1.

1) The unbypassed cathode resistor provides degeneration to obtain high-frequency response.

| INSTRUCTOR'S NOTE: Review the use of degeneration to obtain high-frequency response. |
|---|

2) The gain of V1 is approximately one.

3) Crystal CR1 is a clamping diode that eliminates the pip at the trailing edge of the preknock pulse.

4) The negative pulse is applied to the suppressor grid of V3.

b. The 15-mc carrier is generated by oscillator V2.

1) Impedance Z1 in the grid circuit of V2 determines the output frequency.

2) Feedback is obtained by inductive coupling between the two sections of the inductor.

3) Necessary bias is maintained by the charge on C5.

4) Capacitor C6 is a plate-bypass capacitor.

5) The output, taken from the cathode, is coupled through C9 to the control grid of modulator V3.

→ c. Modulator V3 functions to modulate the carrier with the negative preknock pulse and the positive MTI video.

| INSTRUCTOR'S NOTE: The students have had very little on modulation up to this point. A thorough review should be presented at this time. |
|---|

1) The MTI video is applied to the suppressor grid of V3 through R13, TEST PULSE switch S2, C7, and the parallel combination of C8 and R19.

2) Voltage divider R22 and R23 supplies bias for the suppressor grid.

3) Resistors R24 and R30 provide a fixed bias for the control grid.

4) The output is coupled through C11 to the grid of V4.

d. Tube V4 is an rf amplifier with excellent frequency response.

1) Impedance Z2 in the grid circuit and Z3 in the plate circuit, together with the interelectrode and distributed capacitances, are tuned to 15 megacycles per second.

2) Resistor R28 broadens the frequency response of Z3.

3) The tap on Z3 matches the impedance of the coaxial line.

4) The output is fed to amplifier V1/A16.

e. Tube V1/A16 is an impedance-coupled rf amplifier.

1) The input signal is developed across R1.

2) Resistor R3 broadens the frequency response of L1.

3) The output is coupled through C5 to the delay channel and the top of R5.

4) The output to the delay channel is taken from the top of R5.

5) Resistors R5 and R6 attenuate the signal to the nondelay amplifier by 41 decibels.

→ 3. <u>The MTI Delay Channel Circuit Operation (fig 6-12).</u>

a. The quartz-delay cell Z1 receives the output of V1/A16.

INSTRUCTOR'S NOTE: This is the first delay of this type to which the students have been exposed.

1) The modulated carrier is applied to the input crystal of the delay cell.

2) The input crystal transforms the electrical signal into a mechanical vibration.

3) The mechanical vibrations are transferred to the quartz-delay cell by physical contact.

4) The vibrations travel through the quartz disk and strike a polished surface.

5) The surface reflects the vibrations to a second surface, and so on, until they reach the final surface 1,000 microseconds after entry.

6) A second crystal is in physical contact with the final surface.

7) The crystal converts the mechanical vibrations back into an electrical signal.

b. Tube V3 is a conventional rf amplifier.

1) The input signal from the delay line is developed across R19 and L3.

2) Resistor R25 and C9 provide the cathode bias.

3) Resistor R27 and C10 are a plate-decoupling network.

4) The output, which is coupled through C11, is fed to the control grids of V2A and V2B.

c. Cathode follower V2, a dual triode connected in parallel, isolates the delay cell from the delay amplifier.

1) Capacitor C7 and resistor R24 decouple the plate circuit.

2) Cathode resistor R22 is paralled by R23 and the 0-to-20 db attenuator.

3) The attenuator compensates for gain variations between the delay and nondelay channels.

d. Stages V1 through V4 are identical voltage amplifiers (fig 6-13).

1) The input to V1 is coupled through C1 to the control grid.

2) The AGC voltage is applied to V1 from the junction of R2 and R4.

3) Resistor R3 and capacitor C3 provide cathode bias.

4) Resistor R7 and capacitor C4 form the plate-decoupling network.

5) The output of V1 is coupled through C5, developed across Z1, and applied to the control grid of V2.

6) Stages V2, V3, and V4 operate in a manner identical to that of V1 except that no AGC voltage is applied to them.

e. Power amplifier V5 boosts the signal to the desired level of operation.

1) Resistor R16 and capacitor C15 establish cathode bias.

2) Resistor R18 and capacitor C16 decouple the plate and screen grid.

3) Resistor R7 broadens the frequency response of the primary of T1.

4) The center-tapped secondary of T1 feeds the full-wave rectifier composed of CR1 and CR2.

5) The 15-mc carrier is filtered by L1, C18, and C6.

6) The output, riding at a negative, 4v level, is applied to Z1/A29, the junction of R8 and R9, and the autosync-pulse channel.

f. Delay AGC amplifier V2 functions to maintain the output of the delay amplifier at the negative, 4v level.

1) The voltage at the junction of R8 and R9 is indicated on MTI meter M1/A49.

2) If this level deviates, the change is felt at the grid of V2A.

3) If the output level decreases (becomes more positive), V2A increases conduction.

a) Tube current for V2A flows through common-cathode resistor R7.

b) The resulting bias on V2B decreases conduction in the B-section, and the voltage at the junction of R1 and R2 goes in a positive direction.

c) This rise is coupled to the grid of V1 causing amplification in V1 to increase.

d) The over-all amplification is increased, and the output-level returns to a negative, 4 volts.

4) The output level is determined by the setting of R3.

5) Tube V1A prevents the level of the AGC voltage from rising above ground.

g. Delay line Z1/A29 compensates for circuit delay (fig 6-15).

1) The autosync pulse is delayed somewhat in the autosync-pulse channel.

2) Without compensation for this delay, the delay video would always precede the nondelay video.

4. <u>The MTI Nondelay Channel Circuit Operation (fig 6-14).</u>

a. The input from the MTI modulator undergoes an additional 24 decibels of attenuation in the network of R1, R2, and R3.

1) With the 41 decibels of attenuation in the modulator channel, the total is 65 decibels which is equal to that received by the delay video.

2) The nondelay video is coupled through C1 to the grid of V1.

b. Amplifiers V1 through V5 are identical in operation to the first five stages in the delay amplifier.

c. The AGC amplifier V8 functions much the same as the delay AGC amplifier.

   1) The input to V8 is taken from the junction of R25 and R26 (fig 6-16).

   2) Resistor R43 is set so that the level of the nondelay output is equal in amplitude and opposite in polarity to the output of the delay channel.

   3) If the output level changes, the nondelay AGC amplifier alters the bias on the first stage of the nondelay amplifier to compensate for the change.

d. The output is applied to one end of R25 (fig 6-16).

5. The delay and nondelay video are compared across R25 and R26.

   a. Fixed-target video will cancel.

   b. Moving-target video will not cancel, and it is passed to the MTI video channel.

SUMMARY:

1. The 15-mc carrier, generated in the MTI modulator channel, is used to convey the video through the delay cell.

2. The MTI delay channel provides the 1, 000-microsecond delay for the delay video.

3. The delay AGC amplifier maintains the output level of the delay channel at negative, four volts.

4. The nondelay channel attenuates and amplifies the video by an amount equal to that received in the delay channel.

5. The nondelay AGC amplifier holds the output of the nondelay channel at the same level as that of the delay channel.

COMMON TROUBLES:

| Symptoms | Probable Cause |
|---|---|
| MTI does not function properly. | Improper operating procedure. |
| | MTI system out of adjustment. |

INSTRUCTOR'S NOTE: Explain to the students that, contrary to popular belief, there is no reason why the MTI system should not work. All that it takes is a little time and patience.

# PRACTICAL EXERCISE

## MOVING-TARGET INDICATOR
## (Part I)

AAFCS M33 SETUP:

Equipment will be energized with all time delays expired.

EQUIPMENT NECESSARY: Multimeter and test amplifier.

PRELIMINARY TROUBLES:

There will be no preliminary troubles for this exercise.

DEMONSTRATION:

> INSTRUCTOR'S NOTE: Because of the time involved in making the MTI adjustments, the class will be split into two groups. The first group will proceed as outlined in this exercise excluding the review activities. The second group will be concerned only with the activities listed as location and review. The two groups will be alternated so that maximum time can be given to each student for adjustment and troubleshooting of the MTI system.

1. Locate and Review the Following:

> INSTRUCTOR'S NOTE: Both groups will be together for this function.

   a. ACQ if amplifier,

   b. MTI modulator,

   c. MTI delay channel,

d. MTI nondelay channel,

e. MTI video channel,

f. Autosync channel, and

g. Test-pulse channel.

2. Primary Group Activities.

a. Have students perform MTI field adjustments.

b. If time permits, place defective tubes (or chassis) in the MTI modulator, delay, nondelay, and video channels.

3. Secondary Group Activities.

> INSTRUCTOR'S NOTE: Since the secondary group will be mainly concerned with review activities, it is of the utmost importance that the instructor promote interest along these lines.
>
> Make sure the student so engaged understands what he has learned in the past. Budget your time between groups.

a. Have students review the block diagram of the AAFCS M33.

b. Follow up with the complete block diagram of the acquisition radar.

c. Have students conduct a troubleshooting discussion along the same lines as those used in the conference. This discussion should cover most of the circuitry presented thus far in the course.

> INSTRUCTOR'S NOTE: Supervise student discussions as closely as possible to prevent idle chit-chat.

# LESSON PLAN

## MOVING-TARGET INDICATOR SYSTEM
## (Part II)

OBJECTIVE:

To present the function and the operation of the:

1. MTI video channel,
2. Autosync channel, and
3. MTI test-pulse channel.

INTRODUCTION:

It was shown, in the preceding lesson how the 15-mc carrier was modulated by the preknock and video and how the delay and nondelay video were obtained. The student will learn in this lesson how the delay and nondelay video are compared, how the MTI video is produced, and what happens to the video after it has been produced.

PRESENTATION:

1. MTI System Block Diagram (fig 6-2).

   INSTRUCTOR'S NOTE: The block-diagram discussion should be as complete as time permits.

   a. The MTI modulator channel produces a 15-mc carrier which is modulated by the preknock and video within the channel.

   b. The delay channel delays the modulated signal for 1,000 microseconds.

      1) The signal undergoes approximately 65 db of attenuation in the delay channel.

2) The delay amplifier is controlled so that the output is riding at a negative 4v level.

3) The output is fed to the variable delay line and the autosync channel.

c. The nondelay channel attenuates and amplifies the signal by an amount equal to that received by the signal in the delay channel.

1) The output is held at a positive, 4v level.

2) The rectified signal is fed to the video channel.

d. In the MTI video channel, the video from the delay and nondelay channels is compared.

1) Fixed-target video cancels.

2) Moving-target video does not cancel.

3) The output, negative MTI video, is fed to the switcher-mixer.

e. The autosync channel separates the delayed preknock from the delayed video.

1) The first stage is biased at cutoff so that only the positive preknock is passed while the video is blocked.

2) The preknock at the output of the autosync channel is called the autosync pulse and is used to synchronize the synchronizer.

f. The MTI test-pulse channel produces a pulse used in the alinement of the MTI system.

2. <u>MTI Video Channel Detailed Operation (fig 6-16).</u>

a. The MTI video channel receives the delay and nondelay video which are mixed across R25 and R26 (fig 6-16).

b. Because of the amplitude and phase relationship, the fixed-target returns cancel while moving-target video is applied to the grid of V6.

c. Video amplifier V6 amplifies the MTI video and applies it to CR1 and the grid circuit of V7.

1) The unbypassed cathode resistor provides degeneration for maximum frequency response.

2) Crystal CR1 passes all negative video signals.

d. Tube V7 amplifies and inverts the signal from V6.

1) Resistors R32 and R33 attenuate the input by an amount equal to the gain of V6.

2) This makes sure that the output of V7 is of the same amplitude as that of V6.

3) Crystal CR2 rejects positive signals and passes negative video from V7.

e. The output, negative video, is presented to the switcher-mixer.

3. Autosync-Channel Circuit Operation (fig 6-15).

a. Tube V3 receives the positive, preknock pulse and the negative, delay video at the control grid.

1) Voltage divider R11 and R12 establish a fixed bias which holds V3 near cutoff.

2) Only the positive, preknock pulse is amplified; the delay video is blocked.

3) The signal is coupled through C3 to the control grid of V4.

b. Amplifier stage V4 provides a very fine control over the trigger time of the synchronizer.

1) When the preknock pulse has progressed to this point in the circuit, it has a slight slope in the leading edge.

2) The instant at which the leading edge of the signal reaches an amplitude great enough to trigger the synchronizer is determined by the value of plate-load resistance.

3) Time balance control R15 is adjusted so that the synchronizer is triggered at the desired time.

c. Tube V5 is a dual triode connected to operate as a cathode follower.

1) Bias is developed by voltage divider R18 and R20.

2) Resistor R21 and capacitor C5A form the plate-decoupling circuit.

3) The output is developed across R22.

d. Tube V1/A25 amplifies and inverts the pulse and applies it to blocking oscillator V2/A25.

1) Resistor R3 and capacitor C2 provide cathode bias.

2) Resistor R2 and capacitor C1A compose the screen-decoupling network.

3) Winding 1-2 of T1 serves as the plate load and couples the signal to the remaining windings of T1.

4) Resistor R4 and capacitor C3A are the plate-decoupling network.

4. <u>Test-Pulse Channel Circuit Operation (fig 6-11).</u>

a. Tube V3A receives the sync pulse at its control grid.

1) Bias is obtained from the junction of R13 and R14.

2) The negative output is applied to the plate circuit of V3B.

b. Blocking oscillator V3B provides an output pulse used for adjustment of the MTI system.

   1) Plate voltage is applied when the TEST PULSE switch S2 is in the ON position.

   2) Fixed bias is obtained from voltage divider R19 and R20.

   3) Resistor R15 dampens any oscillations that tend to occur in the unused winding of T1.

   4) Capacitor C7 and resistor R16 form a plate-bypass capacitor.

   5) The output, developed across cathode resistor R18, is applied to the grid of V3/A26 when TEST PULSE switch S2 is in the ON position.

<u>SUMMARY:</u>

1. Fixed-target video will emerge from the delay and nondelay channels at the same instant.

2. Being equal in amplitude and opposite in polarity, fixed-target returns cancel.

3. Moving-target video, having time and amplitude variations, is passed to the MTI video channel.

4. All MTI video presented to the switcher-mixer appears as negative signals at the output of the MTI video channel.

5. The autosync channel triggers the synchronizer at equal intervals.

<u>COMMON TROUBLES:</u>

See lesson plan 17, "Moving-Target Indicator (<u>Part I</u>)."

## PRACTICAL EXERCISE

## MOVING-TARGET INDICATOR
## (Part II)

PROCEDURE:

Refer to practical exercise "Moving-Target Indicator (Part I)," for a breakdown of activities. However, during this period, the two groups as indicated in "MTI (Part I)" will be reversed. The previous primary group will proceed with the activities listed as secondary and vice-versa. Follow the exercise in its entirety, including the location of component parts. Be sure that the student understands that only repetition can result in complete understanding.

# LESSON PLAN

## PLAN-POSITION INDICATOR
## (Part I)

**OBJECTIVE:**

To present the function and operation of the:

1. 4-kc oscillator,

2. ACQ azimuth resolver,

3. Resolver amplifier, and

4. Ring demodulators.

**INTRODUCTION:**

Ever since the beginning of the course, the rotating sweep of the PPI has been taken for granted. It would be impossible to display the video without sweeps on the indicators. This is the first of two lessons which will cover the sweep circuits from the 4-kc oscillator to the electron beam striking the face of the cathode-ray indicator.

**PRESENTATION:**

1. Acquisition Presentation System Block Diagram (fig 7-1).

   a. The sweeps on the PPI's may display 60, 000 or 120, 000 yards of range.

      1) The two PPI's are identical and interchangeable.

      2) The sweeps start from the center of the PPI tube and progress to the outer edge.

      3) The sweep is initiated by the preknock pulse.

4) Sweep rotation is in synchronism with the acquisition antenna.

b. The 4-kc oscillator produces a signal which is applied to the acquisition-azimuth resolver and one of the line-slew resolvers in addition to being used as a reference voltage.

1) Tube V1 is a push-pull oscillator that generates a constant-amplitude 4-kc signal.

2) Push-pull power amplifier V2 and V3 isolate the load from V1.

c. The acquisition-azimuth resolver B2 is located in the antenna-drive unit of the acquisition antenna assembly.

1) To rotate the sweeps of the PPI's, it is necessary to have an electrical signal that corresponds to the mechanical displacement of the antenna.

2) The rotor of the resolver is geared directly to the antenna.

3) The acquisition-azimuth resolver converts the constant-amplitude, 4-kc input into an output signal whose amplitude varies with the rotation of the antenna.

4) Since there are two stator windings physically displaced by 90°, two signals with a 90° phase shift are developed at the output of the resolver.

d. The modulated, 4-kc signal from the resolver is amplified by the resolver amplifier.

1) The resolver amplifier isolates the resolver from its loads.

2) The amplifier consists of two identical channels.

3) The north-south signal is amplified by V1 and V2, and the east-west signal is amplified by V3 and V4.

4) The gain of each channel is approximately one.

5) The resolver-amplifier output is fed to the track-azimuth resolver, the azimuth-line resolver, and the demodulators of each PPI unit.

e. There are two demodulators for each plan-position indicator.

1) All demodulators are interchangeable with each other.

2) The two inputs to the ring demodulator, V1 and V2, are the modulated, 4-kc signal from the resolver amplifier and a constant amplitude, 4-kc carrier from the 4-kc oscillator.

3) Tubes V1 and V2 detect the envelope from the modulated, 4-kc signal and provide two signals 180° out of phase with each other.

4) The 4-kc component is filtered by RC networks in the input circuit to the cathode followers.

5) The two outputs ride at a positive, dc level and vary in amplitude from +3 to +30 volts.

f. The two sweep-generator chassis, one for each PPI, are identical and interchangeable.

1) Each chassis contains four sweep-generator circuits, one for each sweep voltage: the north, south, east, and west.

2) Each circuit is identical.

3) When gated by the range gate, each of these stages produces a trapezoidal voltage.

4) The amplitude of each sweep voltage is determined by the instantaneous amplitude of the associated input from the demodulators.

5) The input amplitude varies in accordance with the rotation of the acquisition antenna.

g. Since the output amplitude of the sweep generator is very low, the sweep amplifiers amplify the sweep signals to a level great enough to obtain proper deflection of the electron beam.

1) There are two sweep amplifier chassis for each PPI. All PPI sweep amplifiers are interchangeable.

2) Each chassis contains two identical channels.

3) The inputs are 180° out of phase; the two amplifiers feed two ends of the deflection coil operating in push-pull.

4) Voltage amplifiers V1 and V2 increase the amplitude of the sweep voltage to a level great enough to operate V4.

5) Tube V3B causes each sweep to start at the same point.

6) Power amplifier V4 is employed to supply the large amount of current needed for electromagnetic deflection.

7) Negative feedback, from V4 to V1, is used to insure linearity.

8) The trapezoidal voltage produces a saw-tooth of current through the deflection coil.

9) Stages V5, V6, V3A, and V7 function exactly like V1, V2, V3B, and V4, respectively.

h. The range gate and intensity limiter gate the sweep generator and unblank the PPI during sweep time.

1) This channel is located on the video amplifier chassis of each PPI unit.

2) Tube V1 is a *one-shot*, cathode-coupled multivibrator triggered by the preknock pulse.

3) The output-pulse width is controlled by the RANGE switch on the front of the PPI.

4) The RANGE switch controls the amount of capacity in the grid circuit of V1B thus controlling the time that V1B is cut off.

5) Tube V2A speeds the action of the multivibrator.

6) Two positive outputs are taken from the plate of V1B.

7) One output, the intensity gate, is coupled to the grid of the 10KP7 PPI tube.

8) The amplitude of the unblanking gate is controlled by limiter V2B and the intensity control.

9) The other output taken from V1B is applied to the control grid of V3B across clamper V3A.

10) Tube V3A clamps the signal so that its positive excursion never exceeds positive, one volt.

11) Since the gate starts at approximately -74 volts, cutoff limiting occurs in the control-grid circuit of V3B.

12) The output of cathode follower V3B, approximately positive, two volts, is fed to the sweep generators.

13) The width of this gate pulse controls the slope of the sweep voltage that is generated in the sweep generator.

14) The length of the sweep on the PPI tube is determined by the amplitude of the sweep voltage, and since the amplitude in either range position remains the same, the sweep length does not change.

15) Since the slope is longer in the 120, 000-yard position, it will take a longer period of time for the sweep to traverse from the center of the screen to the edge.

i. The indicator, high-voltage power supply provides all the necessary high potentials for the PPI, the PI, the trial-fire indicator, and the tracking indicators.

1) Tubes V1 and V2 make up a conventional voltage divider.

2) The output of V1 and V2 is +8.5 kilovolts.

3) A positive, five kilovolts is tapped off a voltage divider that is across the voltage doubler.

4) Tube V3 is a half-wave rectifier giving a positive, 2,000v output.

5) Tube V4 is a half-wave rectifier connected in reverse of V3 thus providing a negative 2,000v output.

2. <u>The 4-kc Oscillator Circuit Operation (fig 7-2).</u>

→ a. Oscillator V1 provides the 4-kc signal.

1) The resonant frequency is determined by the value of L1, C1, C2, and C3.

2) Resistor R2 provides the necessary bias for both tubes.

3) When power is initially applied to V1, one section will conduct more than the other.

4) For purposes of explanation, it will be assumed that V1A starts with higher tube current.

a) The resulting negative swing in plate voltage will be coupled through C1 to the grid of V1B.

b) The plate of V1A will then swing positive, and this rise will be coupled to the grid of V1A through C3.

c) This action will continue until V1A hits maximum conduction.

d) At this instant, the current flowing through L1 tends to remain at a constant value.

e) Pin 4 of L1 swings negative since no voltage is induced from winding 1-2.

f) The negative swing at pin 4 of L1 and the drop in plate voltage of V1B are coupled through C3 to the grid of V1A.

g) The negative-going grid causes V1A to decrease conduction, and pin 1 of L1 becomes more positive.

h) The positive swing at pin 1 is coupled through C1 to the grid of V1B causing heavier conduction.

i) This action will continue until V1B is saturated and reverses the circuit action.

5) Resistor R5 controls the output amplitude.

b. Power amplifiers V2 and V3 use negative feedback to minimize distortion of the signal.

1) Resistors R8 and R13 provide the negative feedback for V2 and V3, respectively.

2) Resistors R10 and R19 are common-cathode resistors for both tubes.

3) The push-pull output is converted to a single-ended signal by grounding one side of the secondary of T4.

c. Tube V4 is a dual triode connected to operate as a cathode follower.

1) LINE ADJ R18 is adjusted so that the range dot and the range circle coincide.

2) The output is developed across R16 and R17 in parallel with L2.

3. The Acquisition-Azimuth Resolver Functions as a Variable Transformer (fig 7-4).

   a. The 4-kc signal varies in amplitude with the rotation of the acquisition antenna.

   b. When the rotor revolves 180°, the 4-kc output signal shifts 180° in phase.

   c. There are two rotor windings physically displaced by 90°.

   d. Because of this displacement, the two output signals have a 90° phase difference.

4. The Resolver Amplifier Receives Plate Voltage Through the ACQUISITION AZIMUTH SCAN Switch (fig 7-4).

   | INSTRUCTOR'S NOTE: Explain that both sections are identical. |
   | --- |

   a. The north-south signal is fed to V1 and the east-west signal to V3.

   b. Tube V1 is a conventional voltage amplifier.

   c. Negative feedback is taken from the secondary of T2 and applied to the grid of V1 through R2 and C7.

   d. Power amplifier V2 provides the necessary current for proper operation.

5. All Demodulators Operate Identically, and Only the North-South Will Be Discussed (fig 7-7).

   a. The 4-kc carrier at the secondary of T2 is approximately twice the amplitude of the modulated signal.

   b. The secondary voltage of T2 controls the conduction of the diodes.

c. When pin 4 of T2 is positive, V1B and V2A conduct.

d. When pin 6 of T2 is positive, V1A and V2B conduct.

e. When the modulated signal and the carrier are in phase, the operation is as follows:

1) *When pin 4 of T1 is positive, current flows from the bottom* of R7 to pins 5 to 6 of T2, through V2A, through pins 4 to 5 of T1, and down through R6 (fig 7-7).

2) *When pin 6 of T1 is positive, current will flow from the* bottom of R7 to pins 5 to 4 of T2, through V2B, through pins 6 to 5 of T1, and down through R6 (fig 7-7).

f. *On the second half of the antenna rotation,* the modulated and carrier signals are 180° out of phase, and the operation will be as follows:

1) *When pin 4 of T1 is positive, current will flow from pin 6* of T1, through V1A, through pins 6 to 5 of T2, down through R7, and up through R6 to pin 5 of T1 (fig 7-7).

2) *When pin 6 of T1 is positive, current will flow from pin 4* of T1 through V1B, through pins 4 to 5 of T2, down through R7, and up through R6 to pin 5 of T1 (fig 7-7).

g. *The voltages developed across R6 and R7 will vary with the* modulated signal and will be 180° out of phase with each other.

h. Cathode follower V3 develops the north and south signals for *application to the sweep generator.*

i. Resistor R8, resistor R9, capacitor C1, and capacitor C2 filter out the 4-kc component.

j. The outputs, developed across resistors R10 and R13, are fed to the sweep generators.

1) *The two signals have a phase difference of 180°.*

2) One signal is termed the north; the other is termed the south.

SUMMARY:

1. PPI range coverage is either 60,000 or 120,000 yards.

2. The acquisition-azimuth resolver converts the mechanical rotation of the antenna into an electrical signal corresponding to that rotation.

3. The resolver amplifier provides isolation between the resolver and its loads.

4. The demodulators detect the envelope of the modulated 4-kc signal.

COMMON TROUBLES:

| Symptoms | Probable Cause |
|---|---|
| 1. Range dot does not appear at the same range as the range circle. | LINE ADJ in the 4-kc oscillator misadjusted. |
| 2. Sweep does not describe a perfect circle. | PPI out of adjustment. |
| 3. Sweeps short on PPI. | Gassy 6AQ5 in the 4-kc oscillator. |

# PRACTICAL EXERCISE

## PLAN-POSITION INDICATOR
## (Part I)

AAFCS M33 SETUP:

The equipment will be completely deenergized.

EQUIPMENT NECESSARY:

1. Multimeter,

2. Test amplifier, and

3. Frequency power meter.

PRELIMINARY TROUBLES:

1. Remove any tube from the STC unit.

2. Remove V5 from the switcher-mixer chassis.

3. Turn all operating controls to minimum.

DEMONSTRATION:

1. Locate and review the following:

   a. 4-kc oscillator,

   b. ACQ resolver,

   c. Resolver amplifier,

   d. PPI demodulators,

   e. PPI sweep generator,

f. PPI sweep amplifiers,

g. PPI range-gate channel,

h. PPI video amplifier, and

i. PPI deflection coils.

2. Locate and explain the following adjustments:

a. Sweep orientation (ACQ azimuth resolver),

b. ACQ ADJ (4-kc oscillator),

c. LINE ADJ (4-kc oscillator),

d. Sweep-amplitude adjustment,

e. Horizontal and vertical balance adjustments,

f. Range-gate adjustment,

g. Focus adjustment, and

h. Positioning adjustment.

| |
|---|
| INSTRUCTOR'S NOTE: Monitor signals as part of the above demonstration. Show unmodulated and modulated, 4-kc at terminals Nos. 106 and 101, respectively.<br><br>Emphasize the importance of symptoms. |

3. Demonstrate complete PPI adjustments.

SUGGESTED TROUBLES:

1. Primary.

a. Replace V1 in the 4-kc oscillator with a defective tube.

b. Turn ACQ ADJ (4-kc oscillator) to minimum.

c. Open terminal No. 93 (fig 7-4), in the radar cabinet.

d. Have each student perform PPI adjustments.

| |
|---|
| <u>INSTRUCTOR'S NOTE</u>: Make note of those students who do not have time to complete field adjustments. Be sure that all students have completed the full adjustment procedure by the end of "Plan-Position Indicator (<u>Part II</u>)." |

2. <u>Review.</u>

a. Have students make power and frequency measurements on the ACQ transmitter.

b. Place a trouble in the computer dc amplifier.

c. Select troubles from primary troubles included in the practical exercises on the ACQ modulator, ACQ receiver, and ACQ AFC.

# LESSON PLAN

## PLAN-POSITION INDICATOR
## (Part II)

OBJECTIVE:

To present the function and operation of the:

1. PPI sweep generators,

2. Sweep amplifiers,

3. Range gate and intensity limiter, and

4. Indicator, high-voltage power supply.

INTRODUCTION:

In the preceding lesson, it was shown how the 4-kc signal is generated and modulated with a voltage that varies in amplitude in accordance with the rotation of the acquisition antenna. The method of extracting the modulation envelope was also discussed. In this lesson, the student will learn the use of the modulation envelope and the remaining circuitry of the plan-position indicators.

PRESENTATION:

1. Plan-position indicator block diagram (fig 7-1).

| |
|---|
| INSTRUCTOR'S NOTE: A thorough review of the PPI system on a block diagram will help the student to retain more of the information presented. The time consumed in review should be scheduled in accordance with that needed for the presentation of the subject matter listed in the objectives. |

a. The 4-kc oscillator generates a signal which is used as a carrier signal for antenna-position data, reference, and in the designation circuits.

**b. The acquisition-azimuth resolver modulates the 4-kc signal in accordance with the position of the acquisition antenna.**

**c. The resolver amplifier isolates the resolver from its loads.**

**d. The demodulators extract the envelopes from the outputs of the resolver amplifier.**

**e. The sweep-generator outputs are controlled in amplitude by the output of the demodulators.**

**f. The sweep amplifiers bring the signal power up to a level sufficient to give proper sweep deflection.**

**2. The sweep generators are identical, and only the south sweep generator will be discussed (fig 7-8).**

**a. In the absence of a gate pulse, V2B is conducting heavily, and C4 has little charge.**

**b. When the positive, gate pulse is applied, V2B cuts off, and C4 begins to charge.**

**1) The voltage appearing at the grid of V1 (in the sweep amplifier) is between the grid and ground.**

**2) Therefore, the voltage at the grid of V1 is the gate pulse plus the charge on C4.**

**3) The signal fed to the sweep amplifier is trapezoidal in shape.**

**3. The sweep amplifiers amplify the trapezoidal input causing a saw-tooth of current to pass through the deflection coils (fig 7-9).**

**a. The cathode of V1 is returned to ground through the cathode resistor of V4 and provides negative feedback.**

**b. The signal from the plate of V2 is coupled through C5 and R9 to the grid of V4.**

c. Tube V3B keeps the grid at a constant negative level so the sweep will start at the center of the PPI.

d. Tube V4 is held at cutoff between sweeps by voltage divider R33, R6, and R12.

e. The output of V4, the south sweep voltage, is applied to pin 1 of the deflection coil.

f. Caution should be exercised when troubleshooting this circuit.

1) Because of feedback, a signal is seen at pin 5 of the tube socket of V1 even with the tube removed.

2) A comparison of signals at identical points of various channels is recommended when troubleshooting.

4. The range gate and intensity limiter provide the gate pulse for the sweep generator and an unblanking pulse for the PPI (fig 7-11).

a. When preknock is applied, V1A starts conducting, and the plate voltage drops.

→ 1) The drop in plate voltage is applied through cathode follower V2A to the grid of V1B.

2) Tube V1B decreases conduction and finally cuts off.

3) The length of time V1B is cutoff is determined by the charge time of C3 or C4, depending on the setting of RANGE switch S1.

b. Clamper V3A holds the top of the waveshape at a few volts positive.

c. The output is fed through cathode follower V3B to the sweep generators.

d. Tube V2B clamps the signal fed to the control grid of the PPI at a potential determined by the setting of R7.

5. The indicator, high-voltage power supply provides operating potentials to all the cathode-ray tubes (fig 19-83).

→ a. Tubes V1 and V2 and capacitors C1 and C2 form a voltage doubler

1) On the first, positive half-cycle, C2 charged through V1 to approximately the voltage across the secondary of T3.

2) On the negative half-cycle, C1 charges to the transformer voltage through V2.

3) On the third, positive half-cycle, the secondaries of T3 and C1 are in series and aiding, and the charge on C2 rises to the transformer voltage plus the charge on C1.

b. The +8, 500v output is developed across the parallel combination of R1 and R2 in series with R6.

c. The +5, 000v output is developed across R6.

d. Capacitors C4 and C5 and resistor R7 filter the +2, 000v output of half-wave rectifier V3.

e. The filter circuit for V4, which provides the negative 2, 000v output, is composed of C6, C7, and R14.

<u>SUMMARY:</u>

1. The sweep generator produces a trapezoidal sweep voltage whose amplitude varies directly with the rotation of the antenna.

2. The sweep amplifiers provide the necessary current for electromagnetic deflection.

3. The range gate starts at preknock time and controls the slope of the trapezoidal sweep voltage.

4. The cathode-ray PPI tube receives an unblanking pulse from the range gate and intensity limiter.

**COMMON TROUBLES:**

| Symptoms | Probable Cause |
|---|---|
| 1. No sweep on PPI. | Frayed or damaged cable conveying range gate to sweep generator. |
| 2. Short or distorted sweep on PPI. | Gassy 6AR5 in the sweep amplifier. |
| 3. Fuse XF 19/A15, 3-amp (slo-blo), blows. | Short in T2 or T3, high-voltage power supply. |

# PRACTICAL EXERCISE

## PLAN-POSITION INDICATOR
## (Part II)

AAFCS M33 SETUP:

The equipment will be completely deenergized.

EQUIPMENT NECESSARY:

1. Multimeter,
2. Test amplifier, and
3. Frequency power meter.

PRELIMINARY TROUBLES:

1. Replace V2 in the pulse synchronizer with a defective tube.
2. Turn the ACQ antenna off.
3. Open the interlock located behind the resolver-amplifier access door.

DEMONSTRATION:

1. Locate and review the following items:

   a. 4-kc oscillator,

   b. ACQ resolver,

   c. Resolver amplifier,

   d. PPI demodulators,

   e. PPI sweep generator,

f. PPI sweep amplifiers,

g. PPI range-gate generator,

h. PPI video amplifier,

i. PPI deflection coils, and

j. Indicator, high-voltage power supply.

2. Demonstrate the removal and replacement of the PPI tube.

| INSTRUCTOR'S NOTE: Caution the students about the danger of mishandling of the PPI tube. |
|---|

SUGGESTED TROUBLES:

1. Primary.

a. Students who have not made PPI adjustments will do so at this time.

b. Remove terminal No. 106 in the radar cabinet.

c. Reverse the connections of terminals Nos. 101 and 102 (sweeps rotate backwards).

d. Remove V1 and V2 from any PPI sweep demodulator.

e. Remove a tube from the PPI sweep generator.

f. Remove a tube from the PPI sweep amplifier.

g. Remove V1 from the PPI video amplifier.

2. Review.

a. Use any troubles listed as primary troubles in previous practical exercises which will not interfere with primary activities in this exercise.

b. Spend some time on chassis location.

c. Have students conduct schematic troubleshooting practice.

# LESSON PLAN

## TARGET DESIGNATOR BLOCK DIAGRAM (fig 8-1)

OBJECTIVE:

To present the function and the operation of the entire target-designator system on a block level.

INTRODUCTION:

During the course to date, the student has learned how the search video is obtained and presented on the PPI and precision indicators. There are many radars that display accurate search information. The greatest advantage that the AAFCS M33 has over these older systems is complete integration between the acquisition and track radars. This lesson will cover, on a block level, the system used for integrating the two radars.

PRESENTATION:

1. In the target designator there are six inputs to the mixer channel.

    a. The acquisition-range mark (QRMK) appears as the range circle.

    b. The acquisition-azimuth mark (QAMK) appears as the flashing azimuth line.

    c. The acquisition-track range mark (QTRMK) appears as the arc portion of the electronic cross.

    d. The track-azimuth gate (TAGA) allows the arc portion of the electronic cross to appear for 10°.

    e. The track-azimuth mark (TAMK) appears as the radial line of the electronic cross.

    f. The track-range gate (TRGA) allows the radial line to appear for 5, 000 yards.

g. The gated marks are mixed with the video in the video-and-mark mixer and presented to the PPI and precision indicators.

2. The mixer channel is a part of the video-and-mark mixer chassis (fig 9-1).

   a. Arc coincidence tube V1 receives the acquisition-track range mark and the track-azimuth gate.

      1) V1 is allowed to conduct for a 10° portion of the track-azimuth gate.

      2) The QTRMK is passed during the conduction time of V1.

   b. Radial-line, coincidence tube V2 is presented with the track-azimuth mark and the track-range gate.

      1) The track-range gate allows V2 to conduct for a period corresponding to 5,000 yards.

      2) The track-azimuth mark is passed during the conduction period of V2.

   c. Clipper amplifier V3 mixes the gated QTRMK and the gated TAMK and presents them to V4.

   d. Amplifier V4 mixes the QTRMK and the TAMK with the QRMK and the QAMK.

   e. Clipper amplifier V6 keeps the marks from attaining an amplitude that would cause blossoming of the PPI's.

   f. The marks are mixed with the video in the grid circuit of V7 and presented to the video amplifiers of the PPI and precision indicators.

3. The range-sweep channel is gated by either the track- or acquisition-range gate to produce the vertical range sweep.

   a. When the TRACK ACQ switch is in the ACQ position, the acquisition-range gate (QRGA) is applied to V1A.

b. V1A is cut off during the time of the gate and allows a capacitor to charge.

c. The sharp leading edge of the gate is applied to the grid of V2 along with the charge on the capacitor which results in a trapezoidal waveshape.

d. The output of V2 is a negative, trapezoidal waveshape with a sharp spike on the leading edge caused by the feedback circuit of V4 and V5.

e. V3 amplifies the signal to bring it up to the proper level for power amplification.

f. Clamper V1B insures the starting of each sweep from the same level.

g. Power amplifiers V4 and V5 are connected in parallel to provide enough current to deflect the electron beam from the bottom to the top of the CRT.

h. When the TRACK ACQ switch is in the TRACK position, circuit action is the same except that the track-range gate replaces the acquisition-range gate.

4. The azimuth-sweep channel causes the electron beam to be deflected from the left edge to the right edge of the cathode-ray tube during the azimuth gate.

a. When the TRACK ACQ switch is in the TRACK position, the E-W signal from the track resolver is applied to the azimuth-sweep channel.

b. When the TRACK ACQ switch is in the ACQ position, the designated E-W signal from the TCC line resolver is applied to the azimuth-sweep channel.

c. The 4-kc carrier is always applied to the azimuth-sweep channel.

d. The ring demodulator composed of V1 and V2 works exactly as do the ring demodulators of the PPI.

e. Limiters V3A and V3B clip most of the positive portion of the input to V4 and V5.

f. V4 and V5 use cutoff limiting.

g. The plate waveforms of V4 and V5 are thus squared off on both the positive and negative excursions.

h. The electron beam will be deflected only when the magnetic field set up by the deflection coil is expanding or contracting.

i. The magnetic field will vary only when the current through the deflection coil is fluctuating.

j. The current through the deflection coil will change in magnitude during the slope between the positive and negative excursions and the extreme negative and positive portions of the signal at the plates of V4 and V5.

k. During normal operation, the electron beam will be deflected from left to right with the PI tube blanked during the portion in which the electron beam would sweep from right to left.

5. The unblanking channel serves to intensify the sweeps during the period in which the range gate and the azimuth gate are in coincidence.

a. The acquisition-range gate and the acquisition-azimuth gate (QAGA) will be applied when the TRACK ACQ switch is in the ACQ position.

b. The track-range gate and the track-azimuth gate will be applied when the TRACK ACQ switch is in the TRACK position.

c. V3A and V3B work together to produce a series of positive, 30-microsecond pulses.

d. The positive pulses will be applied to the control grid of the cathode-ray tube only when both V3A and V3B are cut off.

e. Both triodes are cut off when range-gate pulses occur during the azimuth gate.

## SUMMARY:

1. The mixer channel combines with the video the marks that appear as the flashing azimuth line, the range circle, and the electronic cross.
2. The output of the video-and-mark mixer is applied to the video amplifiers of the PPI and PI.
3. The PI range-sweep channel produces a series of trapezoidal sweep voltages 30 microseconds or 5, 000 yards in duration.
4. The PI azimuth-sweep channel produces a sweep current through the deflection coil for a duration corresponding to 30° of antenna rotation.
5. The undesired secondary azimuth sweep is eliminated because the precision indicator CRT is cut off.
6. The PI is unblanked only during the period in which the range gate and the azimuth gate coincide.
7. When the TRACK ACQ switch is in the TRACK position, the track-range gate and the track-range mark are applied.
8. When the TRACK ACQ switch is in the ACQ position, the acquisition-range gate and the acquisition-azimuth gate are applied.
9. The video amplifier, conventional in design, feeds the video and marks directly to the cathode of the CRT.

# PRACTICAL EXERCISE

## TARGET DESIGNATOR BLOCK DIAGRAM

**AAFCS M33 SETUP:**

Equipment will be completely deenergized.

**EQUIPMENT NECESSARY:**

1. Multimeter,
2. Test amplifier, and
3. Null-voltage test set.

**PRELIMINARY TROUBLES:**

1. Turn all operating controls to minimum.
2. Remove ACQ receiver crystal.
3. Replace V1 in any of the 150v regulators with a defective tube.

**DEMONSTRATION:**

1. Locate and review the following:
   a. TCC line-slew resolver,
   b. TC line-slew resolver,
   c. TCC line resolver,
   d. TC line resolver,
   e. Track-azimuth resolver,
   f. Track-mark generator,

g. Acquisition-mark generator,

h. ACQ range computer and range pot R6, and

i. ACQ range controls.

INSTRUCTOR'S NOTE: As each of the above is covered, trace signals through the block diagram.

2. Have the students locate and monitor the following items.

a. <u>ACQ Range Computer.</u>

1) QRMK.

2) QRGA.

3) DC input to the range computer from the range potentiometer.

b. <u>ACQ Mark Generator.</u>

1) QAMK.

2) QAGA.

3) Resolver inputs.

c. <u>Track-Mark Generator.</u>

1) TAMK.

2) TRGA.

3) Resolver inputs.

d. <u>Track-Range Computer.</u>

1) TRMK.

2) TRGA.

3. Have the students designate and track targets.

| |
|---|
| INSTRUCTOR'S NOTE: For this exercise the class will be split into two groups as soon as the preliminary troubles are cleared from the equipment. While one half of the class is working with the subject matter, the other half should be employed with review activities. |

SUGGESTED TROUBLES:

1. Primary.

   There will be no primary trouble for this exercise.

2. Review.

   a. Have the students perform the daily computer checks.

   b. Replace one of the dc amplifiers with a defective chassis.

   c. Misadjust one of the computer power supplies.

   d. Have the students make checks with the null-voltage test set.

## LESSON PLAN

## TARGET DESIGNATOR
## (Part I)

INSTRUCTOR'S NOTE: This conference will be concluded at the end of the third period. The remaining period will be open time.

### OBJECTIVE:

To present the function and the operation of the:

1. Line resolvers,
2. Line-slew resolvers, and
3. Track-azimuth resolver.

### INTRODUCTION:

Integration of the track and acquisition radars necessitates the use of some system in which the azimuth of both radars can be compared. Since the two are separated by such a great distance, it is much easier to convert the mechanical displacement of the antenna into an electrical signal that is easily conveyed to the desired location. In the AAFCS M33, resolvers are used to convert angular differences into electrical signals.

### PRESENTATION:

1. Designator Control System Detailed Block Diagram (fig 9-1).

INSTRUCTOR'S NOTE: This is the first of three conferences in which the complete block diagram of the designator control system will be covered.

a. The line-slew resolvers control the position of the steady steerable azimuth line.

1) The 4-kc line signal is fed into the line-slew resolver at the tactical control console.

2) The steady steerable azimuth line will appear on the PPI's at a position corresponding to the resultant of the settings of both line-slew resolvers.

3) The output of the line-slew resolvers is fed to both PPI's and is applied to the demodulators when the associated RING DEPRESS switch is activated.

b. The line resolvers control the position of the flashing azimuth line.

1) The modulated, 4-kc signal from the acquisition-azimuth resolver is applied to the line resolver at the tracking console.

2) The output is fed to the acquisition-mark generator and to the azimuth-sweep channel of the precision indicator.

c. The track-azimuth resolver controls the position of the electronic cross in azimuth.

1) The track-azimuth resolver is geared to the track antenna.

2) The input is a modulated, 4-kc signal from the acquisition-azimuth resolver.

3) When the two antennas have the same angular displacement, the E-W output will be zero.

4) The output will also reach a null point when there is a 180° difference between the azimuth of the two resolvers.

5) The output is fed to the track-mark generator and the azimuth-sweep channel of the precision indicator.

d. The track- and acquisition-mark generators are identical and interchangeable.

2. Line Resolvers Circuit Operation (fig 9-2).

| INSTRUCTOR'S NOTE: A good deal of time should be spent in circuit tracing. The student must know the tie-in between the distribution schematics. |
|---|

a. The line resolver B10/B31 receives the N-S and E-W signals from the acquisition-azimuth resolver.

1) The output of the two line resolvers, B10/B31 and B3/C4, will correspond to the angular displacement of the acquisition antenna minus the sum of the settings of B10/B31 and B3/C4.

2) B10 and B3 are mechanically independent of one another; thus, the position of the flashing azimuth line can be controlled from either the tracking console or the tactical control console.

b. The line and line-slew resolvers, although electrically independent, are mechanically coupled together.

3. Line-Slew Resolvers Circuit Operation (fig 9-2).

a. The line-slew resolvers provide a constant-amplitude input to the demodulator when the RING DEPRESS switch is operated.

1) Since the output of the line-slew resolvers is not varying in amplitude, the sweep on the PPI will maintain a steady position.

2) The flashing and steady steerable azimuth lines will occur at the same azimuth because the line and line-slew resolvers at each console are mechanically connected.

b. Capacitors C1, C2, C3, and C4 (fig 7-5) provide a load for resolver B9/B31 when it is not in use.

4. Track-Azimuth Resolver Circuit Operation (fig 9-2).

a. The track-azimuth resolver has an output that corresponds to the differences in azimuth of the two antennas plus 180°.

1) The rotor of the track-azimuth resolver is directly geared to the track antenna.

2) The output has two null points one of which is eliminated in the mark generator.

b. The radial line is developed as a result of the null which occurs when the antennas are in angular coincidence.

| INSTRUCTOR'S NOTE: Explain adjustment of the resolvers. |
|---|

SUMMARY:

1. The line-slew resolvers control the position of the steady steerable azimuth line.

2. The line resolvers control the position of the flashing azimuth line.

3. The track-azimuth resolver controls the position of the electronic cross in azimuth.

COMMON TROUBLES:

| Symptoms | Probable Cause |
|---|---|
| No steady steerable azimuth line. | Cathode follower V4 in the 4-kc oscillator is faulty. |

Note: No further troubles are commonly encountered.

# PRACTICAL EXERCISE

## TARGET DESIGNATOR
## (Part I)

AAFCS M33 SETUP:

The equipment will be completely deenergized.

EQUIPMENT NECESSARY:

1. Multimeter,
2. Test amplifier, and
3. Frequency power meter.

PRELIMINARY TROUBLES:

1. Place a defective tube in the resolver amplifier.
2. Remove the range gate from one of the PPI's.

DEMONSTRATION:

1. Locate and review the function of the following:

   a. TCC and TC line-slew resolvers,

   b. TCC and TC line resolvers,

   c. Track-azimuth resolver,

   d. Track-mark generator,

   e. ACQ mark generator, and

   f. ACQ range computer.

2. Remove V4 in the 4-kc oscillator and point out the symptoms.

3. Use the test amplifier to show the method of checking out a resolver circuit.

| INSTRUCTOR'S NOTE: An ac meter can also be used. |
|---|

4. Demonstrate the adjustment of the track-azimuth resolver.

| INSTRUCTOR'S NOTE: Each student will adjust the track-azimuth resolver. |
|---|

5. Demonstrate the adjustment of the line and line-slew resolvers.

SUGGESTED TROUBLES:

1. Primary.

   a. Open terminal No. 161 (fig 9-2).

   b. Misadjust the line-slew resolver.

   c. Misadjust a line resolver.

   d. Misadjust the track-azimuth resolver.

2. Review.

   a. Have the students take the power and frequency measurements of the acquisition transmitter.

   b. Adjust the preselector.

# LESSON PLAN

## TARGET DESIGNATOR
## (Part II)

**OBJECTIVE:**

To present the function and the operation of the:

1. Track-mark generator, and

2. Acquisition-mark generator.

**INTRODUCTION:**

In the preceding lesson, it was shown how the angular position of each antenna was converted to an electrical signal. To display this information on the PPI and precision indicators, the electrical signal is used to trigger circuits which produce the track-azimuth mark and gate and the acquisition-azimuth mark and gate. It is the null point of the electrical signal which contains the desired information. The mark generators detect the desired null point and eliminate the undesired portion.

**PRESENTATION:**

> INSTRUCTOR'S NOTE: The block-diagram discussion need not be as complete as that given in the preceding discussion. The portion concerning the mark generators should be stressed.

1. Designator Control-System Detailed Block Diagram (fig 9-1).

   a. The line-slew resolvers control the position of the steady steerable azimuth line.

   b. The line resolvers control the position of the flashing azimuth line.

c. The track-azimuth resolver controls the position of the electronic cross in azimuth.

d. The track- and acquisition-mark generators are identical and interchangeable, and only the track-mark generator will be discussed.

1) The N-S signal and the 4-kc carrier are mixed across R20 and fed to amplifier V3A.

2) The N-S signal undergoes a 180° phase shift on the second half of the acquisition-antenna rotation.

3) When the two signals are in phase, they add.

4) When the two signals are out of phase, they subtract.

5) The resultant 4-kc signal, appearing at the grid of V3A, varies in a sine-wave pattern once for each rotation of the acquisition antenna.

6) The output of V3A, varying at the rate of the acquisition-antenna rotation, is fed to the 0.8° and 40° detectors.

7) The E-W signal is applied to V1A.

8) The output of V1A, as a result of limiting action, is constant except at the null points.

9) The limiting action of V1A limits the signal to a point at which the null dip corresponds to 40°.

10) V4 detects the 40° dip and clips a portion of the positive half of the input from V3A.

11) The null points ride on the sine wave at the cathode of V3B.

12) The input stage of the mixer channel is biased so that only 30° of the null waveshape, riding on the positive half of the sine wave, is used.

13) The 0.8° limiter further limits the 40° null.

14) The 0.8° detector detects the null and clips a portion of the positive half of the sine wave.

15) The output is fed to the suppressor grid of coincidence tube V7.

16) The preknock pulse is applied to the control grid and is developed in the plate circuit only during the period when the 0.8° null is riding on the positive portion of the sine wave.

17) During the time of the 0.8° null, many preknock pulses are applied to V6.

18) The purpose of V6 is to trigger V5 only once during the 0.8° null.

19) V5 generates the 735-microsecond, azimuth mark that eventually appears as the radial line of the electronic cross.

20) The mark output of the acquisition-mark generator appears as the flashing azimuth line.

2. Mark-Generator Circuit Operation (fig 9-3).

a. The track-mark generator is located on the precision indicator at the tracking console.

b. The acquisition-mark generator is located on the precision indicator at the tactical control console.

c. The N-S signal and the 4-kc carrier are mixed across R20 and coupled through C14 to V3A.

1) R13 and R15 comprise a voltage divider which supplies bias to the grid of V3A.

2) The output of V3A, a 4-kc signal varying in amplitude in accordance with the rotation of the acquisition antenna, is coupled through C13 to the cathodes of V2A and V4A.

INSTRUCTOR'S NOTE: Review modulation. Use chart to show how the two signals are mixed.

d. The 40° limiter, V1A employs grid and cutoff limiting to clip the positive and negative excursions of the E-W input.

1) The length of the V-shaped dips at the plate of V1A is equal to 40° of antenna rotation.

2) The output is fed to V1B and V4B.

e. V4B detects the envelope of the negative portion of the output of V1A.

1) The envelope, at the plate of V4B, appears as a series of positive, V-shaped 40° pulses.

2) These pulses are fed to the grid of V3B.

f. V4A detects the sine-wave envelope of the output from V3A.

1) The detected signal completes one cycle for each revolution of the acquisition antenna.

2) The positive alternation is clipped because of the cathode potential of V4A.

g. The 40° pulses and the sine-wave output of V4A are combined in the grid circuit of V3B.

1) C5 filters out the 4-kc component.

2) The 40° pulses occur at the extreme positive and negative portions of each sine wave.

3) Only the 40° pulse riding on the positive portion is used as the azimuth gate.

h. The 0.8° limiter V1B further limits the 40° notch.

1) Cutoff and grid limiting are used to accomplish this purpose.

2) The output is fed to detector V2B.

i. The 0.8° detector V2 serves the same purpose as the 40° detector V4.

1) V2B detects the 0.8° notches.

2) V2A detects the envelope of the signal from V3A.

3) The output of V2A and V2B is applied to the suppressor grid of V7.

j. V7 draws plate current only while the 0.8° notch is riding on the positive alternation.

1) The preknock pulse is applied to the control grid.

2) Several preknock pulses are coupled to V5 during the 0.8° notch.

k. The 20,000-microsecond multivibrator V6 is triggered by the first preknock pulse from V7.

1) Before the multivibrator undergoes a complete cycle, the 0.8° notch has ended.

2) The differentiated output is used to trigger multivibrator V5.

l. Multivibrator V5 produces the 735-microsecond, positive azimuth mark.

| |
|---|
| INSTRUCTOR'S NOTE: Explain in detail the use of both the track- and acquisition-mark generators. Go over the complete adjustment procedure. |

SUMMARY:

1. The track-azimuth gate controls the length of the arc portion of the electronic cross and gates the precision indicator in azimuth.

2. The track-azimuth mark appears as the radial line of the electronic cross.

3. The acquisition-azimuth gate gates the presicion-indicator azimuth sweep when the selector switch S1 is in the ACQ position.

4. The acquisition-azimuth mark appears as the flashing azimuth line.

COMMON TROUBLES:

| Symptoms | Probable Cause |
| --- | --- |
| No radial line. | Frayed or damaged cable coupling track-azimuth mark to video-and-mark mixer. |

## PRACTICAL EXERCISE

## TARGET DESIGNATOR
## (Part II)

AAFCS M33 SETUP:

The equipment will be completely deenergized.

EQUIPMENT NECESSARY: Multimeter and test amplifier.

PRELIMINARY TROUBLES:

1. Place a bad tube in the trigger generator.

2. Replace V6 in the switcher-mixer with a bad tube.

DEMONSTRATION:

1. Locate and review the following:

   a. Line-slew resolvers,

   b. Line resolvers,

   c. Track-azimuth resolver,

   d. Track-mark generator,

   e. ACQ mark generator, and

   f. ACQ range computer.

2. Review the use of the multimeter to check the azimuth gate.

3. Have one of the students pull each tube in the mark generator, one at a time, and explain the resulting symptoms.

4. Demonstrate the mark generator adjustments.

5. Have each student make the adjustments.

SUGGESTED TROUBLES:

1. Primary.

   a. Remove tubes from the mark generators and replace them with defective tubes.

   b. Short QAMK at the output of the mark generator.

   c. Open terminal No. 144 in TCC (fig 9-2).

   d. Open terminal No. 66 in TC (fig 9-2).

2. Review.

   a. Place defective tube in AFC LPSA.

   b. Replace V6 in the AFC unit with a defective tube.

   c. Place weak tube in the if preamplifier.

   d. Have students complete as many as possible of the daily checks that do not interfere with primary activities.

# LESSON PLAN

## TARGET DESIGNATOR
## (Part III)

**OBJECTIVE:**

To present the function and operation of the:

1. Acquisition-range control system, and

2. Acquisition-range computer.

**INTRODUCTION:**

The range of the desired target can be designated from either console. The acquisition-range control provides a system for positioning,through electrical means, the unused handwheel and the range potentiometer, at any time the other handwheel is moved. The acquisition-range computer, controlled by the setting of the range potentiometer, yields the acquisition-range mark and the acquisition-range gate. The acquisition-range mark appears as the range circle. The acquisition-range gate is used to gate the range sweep of the precision indicators.

**PRESENTATION:**

1. Target Designator Block Diagram.

> INSTRUCTOR'S NOTE: This is the third coverage of the block diagram. Although the major units should be covered, only the block diagram of the acquisition-range control and range computer need be covered in detail.

a. The line-slew resolvers control the position of the steady steerable azimuth line.

b. The line resolvers control the position of the flashing azimuth line.

c. The track-azimuth resolver controls the position of the electronic cross in azimuth.

d. The track- and acquisition-mark generators are identical and interchangeable.

1) The ACQ azimuth mark appears as the flashing azimuth line.

2) The ACQ azimuth gate is used for unblanking of the precision indicators.

3) The track-azimuth mark appears as the radial line of the electronic cross.

4) The track-azimuth gate gates the ACQ track range mark to produce the arc of the electronic cross and gates the range sweep of the precision indicator.

e. The purpose of the acquisition-range control channel is to provide control of the range circle and the acquisition-range gate from either the tracking console or tactical control console (TCC) (fig 9-1).

1) The acquisition range is controlled by the setting of range pot R9.

2) The output of control transformer B11 is zero when the angular difference of the two resolvers is zero.

3) When K11 is deenergized, control of the acquisition range is at the tracking console.

4) When K11 is energized, control is at the TCC.

5) If the tracking console has control and its handwheel is turned, the setting of the range pot and the rotor of the control transformer change position because of the direct gearing.

a) Since the two resolvers are not in coincidence at this time, a 400-cycle output is applied from B11, through the range coupling network, to $R_q$, the LPSA.

b) The output of $R_q$ is fed through contacts of K11 to motor tachometer V2.

c) B2 changes the position of rotor of B1 until it is in coincidence with the rotor of B11.

d) When the two rotors are in coincidence, circuit action ceases.

6) When control is at the TCC and its handwheel is turned, the rotor of B1 is displaced.

a) B11 will have a 400-cycle output fed to $R_q$.

b) The output of $R_q$ is fed, through contacts of K11, to motor tachometer B12.

c) B12 changes the setting of the range pot and the rotor of B11 until there is no output from B11, at which time circuit action ceases.

f. The acquisition-range channel generates the acquisition-range mark and the acquisition-range gate (fig 9-1).

1) The acquisition-range mark appears at the range circle on the PPI.

2) The acquisition-range gate is used to gate the range sweep of the precision indicator.

3) Clamper V1B holds the plate voltage of the phantastron at the setting of the range pot.

4) Isolation diode V1A prevents the phantastron-plate waveshape from entering the preknock distribution circuits.

5) The leading edge of the negative phantastron output occurs at preknock time.

6) The trailing edge occurs at a time determined by the setting of the range pot.

7) The phantastron pulse is differentiated in the grid circuit of V3B.

8) The negative pip, corresponding to the trailing edge of the output from V2, triggers the gate multivibrator V4.

9) Cathode follower V5B matches the impedance of the coaxial cable used to convey the positive, 30-microsecond range gate.

10) The positive gate is applied to V5A and brings it out of cutoff.

11) When V5A conducts, Z1, the 15-microsecond, quarter-cycle oscillator conducts.

12) The resulting negative waveshape at the grid of V6A causes it to cut off, and the output is a positive waveshape, flat on top with a slight slope on the trailing edge.

13) V6B incorporates saturation limiting, and its output is a reasonably good, negative, square wave.

14) The output of V6B is differentiated in the input circuit to V7.

15) The negative pip at the grid of V7 is cut off owing to the very large cathode resistance.

16) The output of V7, a negative pip, occurs 15 microseconds after the leading edge of the range gate.

17) Transformer T2 inverts the negative, 0.5-microsecond pip and feeds it to the acquisition-range mark distribution.

2. Acquisition Range Control Circuit Operation (fig 9-5).

a. Operation with control at the tracking console.

INSTRUCTOR'S NOTE: This is an excellent opportunity to present a thorough review of servo loops. Trace out the excitation distribution.

1) Relay K11 is deenergized.

2) When the RANGE CIRCLE handwheel is rotated, the range-in-yards counter, the acquisition range pot, the rotors of motor tachometer B12, and the rotor of control transformer B11 are rotated by direct gearing.

3) A signal will be applied from the rotor of B11 through R8, the LPSA, and contacts 10 and 3 of K11, to motor tachometer B2.

4) B2 has excitation applied through contacts 8 and 12 of K11.

5) B2 will drive until the rotor of control-transmitter B1 equals the angular displacement of the rotor of B11.

b. Control is established at the TCC when S1/C14 is operated and applies ground to relay K11.

1) K11 is held in the energized position because of the ground applied through its own contacts 5 and 11 and pushbutton S10/B31.

2) When the RANGE CIRCLE handwheel at the TCC is rotated, the rotor of B1/C14 is displaced.

3) An output will be applied from B11, through R8, LPSA $R_q$, and contacts 10 and 4 of K11, to motor tachometer B12.

4) Excitation is applied to B12 through contacts 7 and 12 of K11.

5) B12 will drive the acquisition range pot. control transformer B11, etc. until the rotor displacement of B11 equals the angular displacement of the rotor of B1.

3. Acquisition Range Unit Circuit Operation (figs 9-6 and 9-7).

a. The acquisition range unit has two inputs.

1) The preknock pulse.

2) The dc control voltage from the range potentiometer.

b. Clamper V1B controls the plate potential of V2.

1) The cathode of V1B is at a potential determined by the setting of the range pot.

2) At any instant that the plate voltage of V2 exceeds the cathode potential of V1B, V1B will conduct, and the increased current through R9 will hold the plate of V2 at the potential at the cathode of V1B.

c. V1A isolates the preknock distribution circuits from the phantastron.

→ d. Phantastron V2 produces at the cathode a negative waveshape with sharp leading and trailing edges.

1) After the sharp negative drop, the pulse decreases toward zero and ends in a sharp rise.

2) The pulse is initiated by the preknock pulse and ends at a time determined by the setting of the range pot.

e. V3A speeds the recovery action of the phantastron circuit to insure readiness for the next cycle.

f. The phantastron output is differentiated in the grid circuit of V3B.

1) C2 and R19 constitute the differentiating circuit.

2) A degenerative feedback is applied from plate to grid, through C5 and R17, to sharpen the resulting pulses.

3) CR1 passes only the negative pip from the plate of V3B, which occurs at the trailing edge of the phantastron pulse, and prevents feedback from V4 to V3B.

g. V4 is the range-gate multivibrator.

1) The output, a positive, 30-microsecond pulse, is taken from the plate of V4A.

2) The setting of R20 controls the pulse width.

h. The output of V4 is fed through cathode follower V5B to the range-gate distribution circuits and to driver V5A.

→ i. V5A acts as a switch that allows Z1 to charge or discharge.

1) V5A is normally cut off by the potential at the grid taken from the junction of R36 and R37.

2) When the gate pulse is applied, V5A allows Z1 to discharge.

3) The output of Z1, taken across the inductance, will swing through only one quarter of an oscillation owing to the grid current's shorting out the inductance when the grid of V6A swings positive.

j. The large negative pulse at the grid of V6A drives it into cutoff and squares the plate waveshape somewhat.

k. The positive pulse at the grid drives V6B to saturation.

1) The negative-plate waveshape is a square wave.

2) Voltage divider R41 and R42 normally holds V6B cut off.

l. The negative pulse, 15 microseconds in duration, is differentiated in the input circuit to V7.

1) C16 and R46 compose the differentiating network.

2) This produces, at the grid, a negative pip occurring at the time of the leading edge of the range gate.

3) The positive pip will occur 15 microseconds later or in the middle of the range gate.

4) V7 is held near cutoff because of the large cathode resistance.

5) The negative pip at the grid is therefore limited.

6) The positive pip at the grid is amplified.

7) The negative pip at the plate is inverted by transformer T2 and is fed to the distribution circuits as a positive, 0.5-microsecond, acquisition-range mark.

SUMMARY:

1. The acquisition-range control channel permits control of the acquisition-range gate and mark from either the tracking console or the tactical control console.

2. The acquisition-range gate gates the precision-indicator range sweep when the selector switch is in the ACQ position.

3. The acquisition-range mark appears as the range circle.

COMMON TROUBLES:

| | Symptoms | Probable Cause |
|---|---|---|
| 1. | No range sweep on PI and no range circle. | Defective V4 in ACQ range computer. |
| 2. | No range circle or range circle for only a portion of the PPI range. | Low preknock or no preknock because of frayed cabling to ACQ range computer or to open plate resistor in preknock cathode follower. |

# PRACTICAL EXERCISE

## TARGET DESIGNATOR
## (Part III)

AAFCS M33 SETUP:

The equipment will be completely deenergized.

EQUIPMENT NECESSARY: Multimeter and test amplifier.

PRELIMINARY TROUBLES:

1. Replace V3 in the track-mark generator with a bad tube.
2. Remove V3 in the 30-second delay timer.
3. Open terminal No. 159 in the radar cabinet (fig 19-62).

DEMONSTRATION:

Locate and review the following items.

1. ACQ Range Control.

   a. B1, control transmitter.

   b. B2, ACQ range motor.

   c. S1, RANGE CIRCLE pushbutton.

   d. B11, control transformer.

   e. B12, ACQ range motor.

   f. Z3, range-coupling unit.

   g. $R_q$, ACQ range LPSA.

h. S10, RANGE CIRCLE pushbutton.

i. Relay K11.

2. ACQ Range Computer.

a. Remove J1, J2, and J3 from the ACQ range computer and note the symptoms.

b. Monitor the signals at J1 and J3.

c. Demonstrate the ACQ range computer adjustment.

d. Demonstrate the ACQ range control adjustment.

e. Show students the use of the RING DEPRESS switch for trouble isolation.

INSTRUCTOR'S NOTE: Each student will perform adjustments.

SUGGESTED TROUBLES:

1. Primary.

a. Open terminal No. 139 in TCC.

b. Open terminal No. 188 in TC.

c. Remove terminal No. 18 in the radar cabinet.

d. Remove V1 in the LPSA $R_q$.

e. Remove, one at a time, various tubes from the ACQ range computer.

2. Review.

a. Some time will be spent on chassis location and general review.

b. Daily computer checks will be reviewed.

c. Place troubles in ACQ transmitter and receiver.

# LESSON PLAN

## TARGET DESIGNATOR
## (Part IV)

OBJECTIVE:

To present the function and operation of the:

1. Target-designator block diagram,
2. Track-range gate cathode follower,
3. Video-and-mark channel, and
4. QTRMK channel.

INTRODUCTION :

In the past few lessons, all the marks and gates that are necessary for PPI and precision-indicator display have been generated. The control circuits for these marks and gates have also been covered. In this lesson, the student will learn how the marks and gates are both mixed together and with the video.

PRESENTATION:

1. Target Designator Block Diagram.

   a. There are six inputs to the mixer channel (fig 9-1).

      1) The acquisition-range mark appears as the range circle.

      2) The acquisition-azimuth mark appears as the flashing azimuth line.

      3) The ACQ track range mark appears as the arc portion of the electronic cross.

4) The track-azimuth gate allows the arc portion of the electronic cross to appear for 10°.

5) The track-azimuth mark appears as the radial line of the electronic cross.

6) The track-range gate allows the radial line to appear for 5,000 yards.

7) The gated marks are mixed with the video in the video-and-mark mixer and presented to the PPI and precision indicators.

b. The mixer channel forms a part of the video-and-mark mixer chassis (fig 9-1).

1) Arc coincidence tube V1 receives the ACQ track range mark and the track-azimuth gate.

a) V1 is allowed to conduct for a 10° portion of the track-azimuth gate.

b) The QTRMK is passed during the conduction time of V1.

2) Radial line, coincidence tube V2 is presented with the track-azimuth mark and the track-range gate.

a) The track-range gate allows V2 to conduct for a period corresponding to 5,000 yards.

b) The track-azimuth mark is passed during the conduction period of V2.

3) Clipper amplifier V3 mixes the gated QTRMK and the gated TAMK and presents them to V4.

4) Amplifier V4 mixes the QTRMK and the TAMK with the QRMK and the QAMK.

5) Clipper amplifier V6 keeps the marks from attaining an amplitude that would cause blossoming of the PPI's.

6) The marks are mixed with the video in the grid circuit of V7 and presented to the video amplifiers of the PPI and precision indicators.

c. The range-sweep channel is gated by either the track- or acquisition-range gate to produce the vertical range sweep (fig 10-1).

| |
|---|
| INSTRUCTOR'S NOTE: The precision-indicator sweep circuits will be covered on a block level in this lesson. |

1) When the TRACK ACQ switch is in the ACQ position, the acquisition-range gate is applied to V1A.

2) V1A is cutoff during the time of the gate and allows a capacitor to charge.

3) The sharp leading edge of the gate is applied to the grid of V2 along with the charge on the capacitor resulting in a trapezoidal waveshape.

4) The output of V2 is a negative, trapezoidal waveshape with a sharp spike on the leading edge caused by the feedback circuit of V4 and V5.

5) V3 amplifies the signal to bring it up to the level for proper amplification.

6) Clamper V1B insures the starting of each sweep from the same level.

7) Power amplifiers V4 and V5 are connected in parallel to provide enough current to deflect the electron beam from the bottom to the top of the CRT.

8) When the TRACK ACQ switch is in the TRACK position, circuit action is the same except that the track-range gate replaces the acquisition-range gate.

d. The azimuth-sweep channel causes the electron beam to be deflected from the left edge to the right edge of the cathode-ray tube during the azimuth gate.

1) When the TRACK ACQ switch is in the TRACK position, the E-W signal from the track resolver is applied to the azimuth-sweep channel.

2) When the TRACK ACQ switch is in the ACQ position, the designated E-W signal from the TCC line resolver is applied to the azimuth-sweep channel.

3) The 4-kc carrier is always applied to the azimuth-sweep channel.

4) The ring demodulator, composed of V1 and V2, works exactly as the ring demodulators of the PPI.

5) Limiters V3A and V3B clip most of the positive portion of the input to V4 and V5.

6) V4 and V5 use cutoff limiting.

7) The plate waveforms of V4 and V5 are thus squared off on both the positive and negative excursions.

8) The electron beam is deflected only when the magnetic field set up by the deflection coil is expanding or contracting.

9) The magnetic field varies only when the current through the deflection coil is fluctuating.

10) The current through the deflection coil changes in magnitude during the slope between the extreme negative and positive portions of the signal at the plates of V4 and V5.

11) During normal operation, the electron beam is deflected from left to right with the PI tube blanked during the portion in which the electron beam would sweep from right to left.

e. The unblanking channel serves to intensify the sweeps during the period in which the range gate and the azimuth gate are in coincidence.

1) The acquisition-range gate and the acquisition-azimuth gate are applied when the TRACK ACQ switch is in the ACQ position.

2) The track-range gate and the track-azimuth gate are applied when the TRACK ACQ switch is in the TRACK position.

3) V3A and V3B work together to produce a series of positive, 30-microsecond pulses.

4) The positive pulses are applied to the control grid of the cathode-ray tube only when both V3A and V3B are cutoff.

5) Both triodes are cut off when range-gate pulses occur during the azimuth gate.

2. <u>Track-Range Gate Cathode Follower Circuit Operation (fig 15-6)</u>.

a. Cathode follower V4A receives the output of the 5,000-yard multivibrator.

1) The output is developed across the cathode resistor R38.

2) C14 and R37 form a plate-decoupling network.

3) Bias is developed across the voltage divider consisting of R33 and R34.

b. The output is coupled to the precision indicators, the video-and-mark mixer, and the trial-fire indicator.

| |
|---|
| INSTRUCTOR'S NOTE: Show the students where the ACQ track range mark originates (on the next page, fig 15-7). |

3. Mixer-Channel Circuit Operation (fig 9-8).

a. Arc-coincidence tube V1 allows the QTRMK to pass for 10°.

1) The QTRMK is continuously applied to the control grid of V1.

2) The TAGA is applied to the suppressor grid of V1.

3) Width control R2 is set so that V1 has plate current flowing for 10°.

4) CR1 prevents any feedback from getting to the plate of V1.

b. Radial line, coincidence tube V2 allows a 30-microsecond portion of the track-azimuth mark to be passed.

1) The track-azimuth mark is applied to the suppressor grid.

2) The track-range gate, applied to the control grid, allows the tube to conduct for 30 microseconds.

3) CR2 provides isolation for V2 from any feed back signals.

c. V3 limits the mixed outputs of V1 and V2 eliminating any tendency of the PPI to blossom at the junction of the arc and radial line.

1) R23 and R26 provide enough bias to hold V3 at the proper level for cutoff limiting.

2) CR3 holds the output of V3 at ground potential.

3) CR4 isolates V3 from unwanted feedback signals.

d. V4 receives the gated QTRMK and TAMK from V3, the QRMK from CR5, and QAMK from CR6.

1) CR5 and CR6 prevent feedback to the acquisition-range computer and the acquisition-mark generator.

2) The marks are mixed across R30 and applied to the grid of V4 through C13.

3) Degeneration introduced by R35 improves the frequency response.

e. The output of V4 is applied to limiter V6.

1) V6 is biased near cutoff to provide cutoff limiting which prevents blossoming of the PPI at any point where the marks coincide.

2) R50 is adjusted for proper intensity of the marks on the PPI.

3) The output signals are mixed with the video in the input circuit to V7.

SUMMARY:

1. The mixer channel combines with the video the marks that appear as the flashing azimuth line, range circle, and electronic cross.

2. The output of the video-and-mark mixer is applied to the video amplifiers of the PPI and PI.

3. The video amplifier, conventional in design, feeds the video and marks directly to the cathode of the CRT.

INSTRUCTOR'S NOTE: Review the use of each mark and gate during the summary.

COMMON TROUBLES:

| | Symptoms | Probable Cause |
|---|---|---|
| 1. | Loss of radial line from electronic cross. | V2, video-and-mark mixer, defective. |
| 2. | Loss of arc from electronic cross. | V1, video-and-mark mixer, defective. |

IA-P25

# PRACTICAL EXERCISE

## TARGET DESIGNATOR
## (Part IV)

AAFCS M33 SETUP:

The equipment will be completely deenergized.

EQUIPMENT NECESSARY:

1. Test amplifier,
2. Multimeter,
3. Frequency power meter, and
4. Null-voltage test set.

PRELIMINARY TROUBLES:

1. Open the low-voltage interlock.
2. Misadjust the 320v power supply.
3. Place bad tube in the series regulator.
4. Turn all operating controls to minimum.
5. Extract pick-up probe to AFC mixer.
6. Turn capsule voltage to minimum.

DEMONSTRATION:

1. Locate and review the following:

   a. Line-slew resolvers,

b. Line resolvers,

c. Track-azimuth resolver,

d. Track-mark generator,

e. ACQ mark generator,

f. ACQ range computer,

g. Track-range computer, and

h. Video-and-mark mixer.

2. Monitor all the signal inputs to the video-and-mark mixer.

3. Remove tubes from video-and-mark mixer and note symptoms.

4. Remove track-range gate cathode follower from the track-range computer and note symptoms.

SUGGESTED TROUBLES:

1. Primary.

a. Place troubles in the video-and-mark mixer.

b. Place troubles in the TRGA cathode follower and QTRMK channel.

c. Place troubles in any of the following:

1) The mark generators,

2) The 4-kc oscillator,

3) The ACQ range computer, and

4) The designator resolver circuits.

INSTRUCTOR'S NOTE: This exercise will serve as a review of the designation-control system.

2. Review.

a. Measure frequency and power with the frequency power meter.

b. Have students perform computer daily checks.

c. Make various checks with null-voltage test set.

d. Misadjust computer power supplies.

e. Place a faulty dc amplifier in the computer.

f. Show students how to balance the computer modulators.

# LESSON PLAN

## DESIGNATION-PRECISION INDICATOR

**OBJECTIVE:**

To present the function and operation of the:

1. Mixer-channel block diagram,
2. Precision-indicator block diagram,
3. Precision-indicator range-sweep channel,
4. Precision-indicator azimuth-sweep channel, and
5. Unblanking channel.

**INTRODUCTION:**

In previous lessons, the operation of the various circuits which generate the marks and gates needed for the designation system were covered. Before the marks can be displayed on the precision indicator, there must be sweep voltages generated to displace the electron beam. The sweep must move from left to right, representing the azimuth sweep of the antenna, and from the bottom to the top, corresponding to range. In this lesson, the range- and azimuth-sweep circuits will be covered in detail.

**PRESENTATION:**

1. Target Designator Block Diagram (figs 9-1 and 10-1).

| |
|---|
| INSTRUCTOR'S NOTE: This is the second coverage of this block. Emphasis should be placed on the sweep circuits. |

a. There are six inputs to the mixer channel (fig 9-1).

1) The acquisition-range mark appears as the range circle.

2) The acquisition-azimuth mark appears as the flashing azimuth line.

3) The ACQ track range mark appears as the arc portion of the electronic cross.

4) The track-azimuth gate allows the arc portion of the electronic cross to appear for 10°.

5) The track-azimuth mark appears as the radial line of the electronic cross.

6) The track-range gate allows the radial line to appear for 5, 000 yards.

7) The gated marks are mixed with the video in the video-and-mark mixer and presented to the PPI and precision indicators.

b. The mixer channel forms a part of the video-and-mark mixer chassis.

1) Arc-coincidence tube V1 receives the acquisition-track range mark and the track-azimuth gate.

a) V1 is allowed to conduct for a 10° portion of the track-azimuth gate.

b) The QTRMK is passed during the conduction time of V1.

2) Radial line, coincidence tube V2 is presented with the track-azimuth mark and the track-range gate.

a) The track-range gate allows V2 to conduct for a period corresponding to 5, 000 yards.

b) The track-azimuth mark is passed during the conduction period of V2.

3) Clipper amplifier V3 mixes the gated QTRMK and the gated TAMK and presents them to V4.

4) Amplifier V4 mixes the QTRMK and the TAMK with the QRMK and the QAMK.

5) Clipper amplifier V6 keeps the marks from attaining an amplitude that would cause blossoming of the PPI's.

6) The marks are mixed with the video in the grid circuit of V7 and presented to the video amplifiers of the PPI and precision indicators.

c. The range-sweep channel is gated by either the track- or ACQ-range gate to produce the vertical range sweep (fig 10-1).

1) When the TRACK ACQ switch is in the ACQ position, the acquisition-range gate is applied to V1A.

2) V1A is cutoff during the time of the gate and allows a capacitor to charge.

3) The sharp leading edge of the gate is applied to the grid of V2 along with the charge on the capacitor and results in a trapezoidal waveshape.

4) The output of V2 is a negative, trapezoidal waveshape with a sharp spike on the leading edge caused by the feedback circuit of V4 and V5.

5) V3 amplifies the signal to bring it up to the proper level for power amplification.

6) Clamper V1B insures the starting of each sweep from the same level.

7) Power amplifiers V4 and V5 are connected in parallel to provide enough current to deflect the electron beam from the bottom to the top of the CRT.

8) When the TRACK ACQ switch is in the TRACK position, circuit action is the same except that the track-range gate replaces the acquisition-range gate.

d. The azimuth-sweep channel causes the electron beam to be deflected from the left edge to the right edge of the cathode-ray tube during the azimuth gate.

1) When the TRACK ACQ switch is in the TRACK position, the E-W signal from the track resolver is applied to the azimuth-sweep channel.

2) When the TRACK ACQ switch is in the ACQ position, the designated E-W signal from the TCC line resolver is applied to the azimuth-sweep channel.

3) The 4-kc carrier is always applied to the azimuth-sweep channel.

4) The ring demodulator composed of V1 and V2 works exactly like the ring demodulators of the PPI.

5) Limiters V3A and V3B clip most of the positive portion of the input to V4 and V5.

6) V4 and V5 use cutoff limiting.

7) The waveform at the plates of V4 and V5 is thus squared off on both the positive and negative excursions.

8) The electron beam is deflected only when the magnetic field set up by the deflection coil is expanding or contracting.

9) The magnetic field varies only when the current through the deflection coil is fluctuating.

10) The current through the deflection coil changes in magnitude during the slope of the positive and negative excursions between the extreme negative and positive portions of the signal at the plates of V4 and V5.

11) During normal operation the electron beam is deflected from left to right, and the PI tube is blanked during the portion in which the electron beam would sweep from right to left.

e. The unblanking channel serves to intensify the sweeps during the period in which the range gate and the azimuth gate are in coincidence.

1) The acquisition-range gate and the acquisition-azimuth gate will be applied when the TRACK ACQ switch is in the ACQ position.

2) The track-range gate and the track-azimuth gate will be applied when the TRACK ACQ switch is in the TRACK position.

3) V3A and V3B work together to produce a series of positive, 30-microsecond pulses.

4) The positive pulses are applied to the control grid of the cathode-ray tube only when both V3A and V3B are cut off.

5) Both triodes are cut off when range-gate pulses occur during the azimuth gate.

2. <u>Range-Sweep Channel Circuit Operation (fig 10-2).</u>

a. The positive, 30-microsecond range gate is applied to sweep-generator V1A.

1) Normally V1A is conducting heavily, and the charge across C1 is very low.

2) When the gate is applied to the cathode, V1A cuts off.

3) When V1A is cut off, C1 starts to charge.

4) In addition to the charge on C1, a small portion of the gate pulse is developed across R4.

b. The signal applied to the grid of V2 is a trapezoidal waveshape.

1) Degeneration, to maintain the proper waveshape, is provided by parallel cathode resistors R23 and R27 which also serve as common-cathode resistors for V4 and V5.

2) The output is coupled to V3 through C3.

c. V3 is a conventional voltage amplifier.

d. Clamper V1B maintains the signal at a constant reference level.

e. Power amplifiers V4 and V5 are connected in parallel.

1) The plate load for both tubes is the deflection coil of the PI tube.

2) A feedback to V2 is developed by R23 and R27.

3) In addition to the feedback, R17 provides cathode bias for V2.

4) At the leading edge of the trapezoidal voltage, the high-frequency component effectively shorts out R17 through C6.

5) During this time V2 has very high gain that causes a sharp drop in the plate voltage of V2.

6) The shorting effect of C6 is quickly removed, and the plate voltage of V2 quickly rises and then decreases proportionally with the charge on C1.

7) This produces a sharp spike in the leading portion of the of the trapezoidal waveshape.

8) The spike is desired to overcome the inductive effect of the deflection coil which opposes a change in current.

9) R25 provides an additional feedback voltage.

3. Azimuth-Sweep Channel Circuit Operation (fig 10-2).

a. Ring demodulator V1 and V2 receives the modulated E-W signal and the 4-kc carrier.

1) The carrier acts as a switch to control the conduction of V1 and V2.

2) When pin 4 is positive with respect to pin 6, V1A and V2B conduct.

3) When pin 6 is positive with respect to pin 4, V1B and V2A conduct.

4) Circuit action with the modulated signal is identical to the ring demodulators of the PPI's, and reference should be made to the presentation system lesson plan for detailed explanation (Plan-Position Indicator (Part I)).

b. A push-pull signal is fed across limiters V3A and V3B to the grids of V4 and V5.

1) V3A and V3B are held at cutoff by a negative voltage taken from the junction of R7 and R11.

2) Limiters V3A and V3B conduct when the plates become more positive than the cathode and square off the positive portion of the inputs to V4 and V5.

3) V4 and V5 employ cutoff limiting and limit the negative portion of the input signals.

4) The current through the deflection coil will vary only during the switchover period between the positive and negative excursions when the voltage is changing rapidly.

5) R17 is positioned for the correct starting point of the horizontal sweep.

6) The undesired right-to-left sweep is eliminated since the PI tube is blanked out at that time.

4. Unblanking-Channel Circuit Operation (fig 10-3).

a. V3A and V3B work together to produce a series of 30-microsecond, unblanking pulses for the duration of the azimuth gate.

b. V3A conducts in the absence of the azimuth gate.

1) In the absence of the gate, the cathode is sufficiently negative to allow heavy conduction through V3A.

2) The plate of V3A is connected directly to the grid of V3B.

3) When V3A conducts, plate current flows from the top of R4, through R5 and R7, to ground (fig 10-3).

4) This provides a negative bias to the grid of V3B and cuts it off.

5) No unblanking pulses are coupled through C4 to the CRT while V3B is cutoff.

c. When the azimuth gate is applied, V3A is cut off.

1) The plate of V3A is at a more positive potential at this time.

2) V3B will conduct heavily because of the increased positive potential at the grid.

3) The plate voltage of V3B becomes less positive, but no signal is fed to the grid of the CRT since the plate voltage is not changing rapidly.

4) With V3B conducting, the range gate is applied to the cathode.

5) The range gate cuts V3B off for 30 microseconds.

6) The result is a series of positive, 30-microsecond pulses to the grid of the CRT.

d. Intensity control R5 establishes the level at which the unblanking pulses ride.

INSTRUCTOR'S NOTE: Outline the adjustments procedure for the precision indicator.

5. Video Amplifier Review (fig 10-3).

a. The input contains the video and components of the range circle, the flashing azimuth line, and the electronic cross.

b. V2 is a conventional video amplifier.

1) $R_g$ is the gain potentiometer on the front of the precision indicator.

2) The output, negative video and marks, is fed directly to the cathode of the cathode-ray tube.

SUMMARY:

1. The range-sweep channel produces a series of trapezoidal sweep voltages 30 microseconds or 5, 000 yards in duration.

2. The azimuth-sweep channel produces a sweep current through the deflection coil for a duration corresponding to 30° of antenna rotation.

3. The undesired secondary azimuth sweep is eliminated by the precision indicator CRT's being cut off.

4. The PI is unblanked only during the period in which the range gate and the azimuth gate coincide.

5. When the TRACK ACQ switch is in the TRACK position, the track-range gate and the track-range mark are applied.

6. When the TRACK ACQ switch is in the ACQ position, the acquisition-range gate and the acquisition-azimuth gate are applied.

**COMMON TROUBLES:**

| Symptom | Probable Cause |
| --- | --- |
| No range sweep on PI. | Resistor R26 of the range-sweep generator open. |

# PRACTICAL EXERCISE

## DESIGNATION-PRECISION INDICATOR

AAFCS M33 SETUP:

The equipment will be completely deenergized.

EQUIPMENT NECESSARY: Test amplifier and multimeter.

PRELIMINARY TROUBLES:

1. Open the low-voltage interlock.
2. Remove ACQ receiver crystal.
3. Remove tube from STC unit.

DEMONSTRATION:

1. Locate and review the following:
   a. Range-sweep channel,
   b. Azimuth-sweep channel,
   c. Unblanking channel, and
   d. Video amplifier.
2. Monitor signals throughout the precision indicator.
3. Demonstrate the precision-indicator field adjustments.
4. Have each student perform the adjustments.

SUGGESTED TROUBLES:

1. Primary.

Place troubles in each of the following channels:

a. Range sweep,

b. Azimuth,

c. Range gate, and

d. Video.

2. Review.

Review activities are to be selected at random from previous exercises.

> INSTRUCTOR'S NOTE: The review activities selected should not interfere with the primary activities of this exercise.

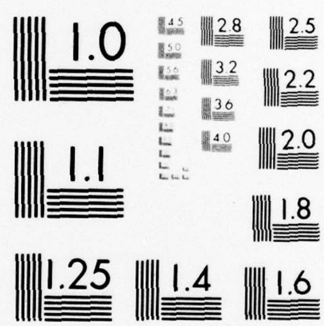
AD-A071 775 HUMAN RESOURCES RESEARCH ORGANIZATION ALEXANDRIA VA F/G 5/2
AAFCS M33 TECHNICIAN TRAINING PROGRAM. VOLUME III. ACQUISITION --ETC(U)
JUN 58 DA-49-106-QM-1

UNCLASSIFIED NL

4 OF 4

AD A071775

END
DATE
FILMED
8-79
DDC




MICROCOPY RESOLUTION TEST CHART
NATIONAL BUREAU OF STANDARDS-1963-A

# LESSON PLAN

## ACQUISITION RADAR REVIEW

**OBJECTIVE:**

To present a review of the function of all major units in the acquisition radar.

**INTRODUCTION:**

Before studying the track radar system, it is best to review and tie-in all the information gathered up to this point. The purpose of this lesson is to sum up the data and troubleshooting procedures which have been covered to date.

**PRESENTATION:**

| INSTRUCTOR'S NOTE: Troubleshooting procedures will be covered for each block. |
|---|

1. Acquisition Radar Simplified Block Diagram (fig 1-1).

   a. Synchronizer-System Outputs.

      1) The sync pulse triggers the transmitter.

      2) The preknock pulse establishes a timing reference for the range and sweep circuits.

      3) The test pulse is used for the alinement of the moving-target indicator.

   b. Transmitter Characteristics.

      1) The peak power output is approximately one megawatt.

      2) The pulse width is 1.3 microseconds.

3) The prf is 1,000 pulses per second.

4) The frequency range is from 3,100 to 3,500 megacycles.

c. Composition of the RF System.

1) A waveguide.

2) A duplexer.

3) A directional coupler.

4) A pillbox radiator.

d. The Receiver.

1) Converts the return echo to an if signal.

2) Employs AFC to maintain the intermediate frequency at 60 mc per second.

3) Amplifies and detects the if signal.

4) Uses MTI to show only moving targets and to eliminate ground clutter.

e. Acquisition-Presentation System.

1) The resolver channel converts the mechanical rotation of the antenna into an electrical signal that is used to rotate the sweep on the PPI in synchronism with the antenna.

2) The PPI shows all targets in the surrounding area to a maximum range of 120,000 yards.

3) The precision indicator shows an enlarged view of a 5,000-yard by 30° segment of the PPI presentation.

2. Pulse-Synchronizer Characteristics.

a. The synchronizer pulse is a 20v, 2-microsecond, positive pulse.

b. The preknock pulse is a 25v, 2-microsecond, positive pulse.

c. The test pulse is a 6v, 7- to 9-microsecond, positive pulse.

d. The pulse repetition rate is 1,000 pulses per second.

3. The Transmitter-System Functional Block (fig 4).

a. The trigger generator, triggered by the synchronizer pulse, has an output of sufficient amplitude to trigger the modulator.

b. The modulator, when triggered, allows the pulse-forming network to discharge through the pulse transformer.

c. The pulse transformer steps up the pulse amplitude to 38-45 kv.

d. The magnetron oscillates during pulse time and feeds the rf burst of energy to the rf system.

4. RF System Functional Block (fig 5-1).

a. The waveguide couples the rf energy to the pillbox radiator.

b. The AFC sampler couples a sample of the radiated pulse to the AFC mixer.

c. The ATR tubes prevent the return echo from being absorbed by the magnetron.

d. The TR tube prevents the transmitted pulse from saturating the receiver.

e. The directional coupler is used for making power, frequency, and standing-wave ratio measurements.

f. The rotary joint permits transfer of energy through the waveguide while the antenna is rotating.

g. The pillbox radiator forms the rf energy into a beam which is narrow in azimuth and broad in elevation and radiates it into space.

5. Receiver-System Functional Block (fig 6).

a. The preselector passes the desired signal while reflecting all others.

b. The signal mixer mixes the return signal with the input from the local oscillator to produce the 60-mc intermediate frequency.

c. The if amplifier channel amplifies and detects the if signal.

1) The if preamplifier boosts the signal to establish a high signal-to-noise ratio and overcome cable losses.

2) The attenuator compensates for gain variations in the receiver system.

3) The if amplifier has a gain of approximately 1,000,000.

a) Negative, bypass video is fed to the switcher-mixer.

b) Positive, MTI video is sent to the carrier generator.

d. The MTI channel consists of the following:

1) The carrier generator which modulates the carrier with the if signal and the preknock pulse,

2) The delay-cell amplifier which sends one output to the delay line and the other to the nondelay amplifier, and

3) The video-and-synchronizer unit which compares the outputs of the delay and nondelay channels to produce moving-target video.

e. The switcher-mixer selects either the MTI or bypass video for eventual application to the screens.

f. The sensitivity time control reduces the receiver gain for close-in targets thus reducing the blossoming effect at the center of the PPI's.

g. The automatic frequency control provides continuous frequency correction for the local oscillator and the preselector.

6. Acquisition-Presentation System Functional Block (fig 7).

a. The 4-kc oscillator produces a signal which is applied to the acquisition-azimuth resolver and one of the line-slew resolvers in addition to being used as a reference voltage.

b. The acquisition-azimuth resolver converts the constant amplitude, 4-kc input into an output whose amplitude varies with the rotation of the antenna.

c. The modulated, 4-kc signal from the resolver is amplified by the resolver amplifier.

d. There are two demodulators for each plan-position indicator which detect the envelope of the modulated, 4-kc signal.

e. The two sweep-generator chassis when gated by the range gate produce four trapezoidal voltages.

f. Since the output amplitude of the sweep generator is very low, the sweep amplifiers amplify the sweep signals to a level great enough to obtain proper deflection of the electron beam.

g. The range gate and intensity limiter gate the sweep generator and unblank the PPI during sweep time.

7. Designation System (fig 9).

a. The Resolver Channel.

1) Provides an electrical signal which causes the PPI sweeps to rotate in synchronism with the acquisition antenna.

2) Outputs are also used to control the position of both the steady and flashing steerable azimuth lines.

3) Determines the azimuth at which the electronic cross will appear on both PPI's.

b. Acquisition-Mark Generator.

1) Receives the preknock pulse, the acquisition N-S and E-W resolver signals, and the 4-kc carrier.

2) The two output signals are the acquisition-azimuth mark and the acquisition-azimuth gate.

a) The acquisition-azimuth mark appears as the flashing steerable azimuth line.

b) The acquisition-azimuth gate is used to unblank the precision indicators when the TRACK ACQ switch is in the ACQ position.

c. The Track-Mark Generator.

1) Receives the N-S and E-W resolver signals from the track-azimuth resolver.

2) The two mark generators are identical and interchangeable.

3) The outputs of the track-mark generator are the track-azimuth mark and gate.

a) The track-azimuth mark appears as the radial line of the electronic cross.

b) The track-azimuth gate gates the track-range mark to produce the 10° arc of the electronic cross, and it is used for unblanking of the precision indicators when the TRACK ACQ switch is in the TRACK position.

d. The acquisition-range computer. Outputs are the acquisition-range mark and the acquisition-range gate.

1) The acquisition-range mark appears as the range circle.

2) The acquisition-range gate serves to unblank the precision indicators when the TRACK-ACQ switch is in the ACQ position.

e. There are six inputs to the mixer channel.

1) The acquisition-range mark appears as the range circle.

2) The acquisition-azimuth mark appears as the flashing azimuth line.

3) The ACQ track range mark appears as the arc portion of the electronic cross.

4) The track-azimuth gate allows the arc portion of the electronic cross to appear for 10°.

5) The track-azimuth mark appears as the radial line of the electronic cross.

6) The track-range gate allows the radial line to appear for 5,000 yards.

7) The gated marks are mixed with the video in the video-and-mark mixer and presented to the PPI and precision indicators.

f. <u>The Precision Indicators (fig 10)</u>.

1) Permit coordinated action between the acquisition and track radars.

2) The point about which the sector of display is centered depends upon the position of the associated TRACK ACQ switch.

3) The range-sweep channel is gated by either the track or ACQ range gate to produce the vertical range sweep.

4) The azimuth-sweep channel causes the electron beam to be deflected from the left edge to the right of the cathode-ray tube during the azimuth gate.

5) The unblanking channel serves to intensify the sweeps during the period in which the range gate and the azimuth gate are in coincidence.

## PRACTICAL EXERCISE

## ACQUISITION RADAR REVIEW

INSTRUCTOR'S NOTE: Practical exercises 1 through 26 will be used as a source for all activities under the heading of:

1. Preliminary troubles,
2. Primary troubles, and
3. Review troubles and activities.

AAFCS M33 SETUP:

The equipment will be completely deenergized.

EQUIPMENT NECESSARY:

1. Test amplifier,
2. Multimeter, and
3. Null-voltage test set.

DEMONSTRATION:

There will be no demonstration.

IA-P27

SUGGESTED TROUBLES:

1. Primary.

   Refer to practical exercises 1 through 26.

2. Review.

   Refer to practical exercises 1 through 25.

Army, Fort Bliss, Texas
HumRRO 108313